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BLACK-FOOTED FERRET ANNOTATED BIBLIOGRAPHY, 1986-1990

Montana BLM Wildlife Technical Bulletin No. 3

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BLACK-FOOTED FERRET ANNOTATED BIBLIOGRAPHY, 1986-1990

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INTRODUCTION

Conservation and management of endangered species is often complex, uncertain, and urgent. Managers, as well as researchers, need current and reliable information as they work towards species restoration. Having an up-to-date working knowledge of the species, the problems it faces, and options for solutions to these problems is essential. This annotated bibliography provides a readily accessible source of recent information on the black-footed ferret (BFF; *Mustela nigripes*). An overview of the conservation biology of the BFF was given by Clark (1989) summarizing much of the research and management effort to restore the species. This bibliography builds on an earlier ferret literature compilation by Casey et al. (1986). Casey et al. (1986) listed 351 citations published between 1851 and 1986 and we list 118 articles published between 1986 and 1990. Two companion Montana BLM wildlife technical bulletins support this bibliography, one a bibliography on prairie dogs (Clark 1986) and the other a volume on managing biodiversity on the prairie dog ecosystem (Clark et al. 1989).

In preparing this bibliography, we received assistance from several people and organizations. Dan Hinckley of the Montana Bureau of Land Management, Arnold Dood and Dennis Flath of the Montana Department of Fish, Wildlife, and Parks, Brain Miller and Dave Wildt of the National Zoo, Ron Crete and Dean Biggins of the U.S. Fish and Wildlife Service, and Steve Minta of the Northern Rockies Conservation Cooperative provided assistance in locating documents. We were supported by the Bureau of Land Management, the Cathy Patrick Foundation, the Chicago Zoological Society, The Eppley Foundation for Research, Hopie and Bob Stevens of the Fanwood Foundation, Emily Swanson of the Lost Arrow Corporation, the Montana Department of Fish, Wildlife, and Parks, the New-Lands Foundation, Nancy Kittle of Nu Lambda Trust, and World Wildlife Fund-US. We thank you all.

METHODS

Our methods conformed to those of Casey et al. (1986). We included references from scientific journals, published books, dissertations, and some popular articles and government reports. Newspaper articles were not included. We included a few key references on prairie dogs (*Cynomys* spp.), because prairie dog colonies are ferret habitat. We also included a few citations on related ferret species if they referred to BFFs or BFF recovery. Most entries were annotated with abstracts, summaries, or highlights. The 118 entries were categorized by subject for ease of reference. Using Casey et al. (1986) and this publication, we analyzed trends in ferret publications over time, including number of articles published per year, number of authors per publication, total number of authors publishing, primary author affiliation, and subject matter.

RESULTS AND DISCUSSION

Casey et al. (1986) described the BFF literature prior to 1986, listing 351 references. Before 1900, most publications consisted of species descriptions. Articles published between 1900 and 1964 were primarily reports of the ferret's distribution. Articles appearing from 1965 to 1980 dealt with the results of biological and ecological research performed on the Mellette County, South Dakota, population of ferrets. From 1981 to 1985, publications contained both research results from studies on the Meeteetse, Wyoming, population of ferrets and research and management aimed at finding ferrets in and reintroducing them to other locations.

Canine distemper largely destroyed the Meeteetse population in 1985 and by 1987 the last known wild population of black-footed ferrets was extinct (Forrest et al. 1988, Thorne and Williams 1988, Williams et al. 1988, Clark 1989). Eighteen ferrets were taken into captivity and are being bred to increase population size for eventual release to the wild. The literature for these years reflected these events. During the past 5 years most of the literature fell into one of four major categories. First, much of the remaining ecological data from Meeteetse was analyzed and published. Second, articles appeared which defended or criticized management of the

Meeteetse BFF population. Third, several articles discussed management of the captive population(s), focusing primarily on genetic and demographic considerations. Lastly, a number of articles analyzed potential habitat and reintroduction sites, especially with respect to prairie dog colony dynamics.

Figure 1 presents the percentage of articles published in each of seven subject catagories from 1960-1989. The percentage of general, non-technical papers decreased over the last 30 years, while the percentage of articles dealing with the management of BFFs in the wild and captivity increased. The percentage of articles addressing ecological topics also increased, especially in the last 10 years. The percentage of articles dealing with phylogeny, physiology or behavior, and disease remained about the same. Interestingly, although the last wild population of BFFs and their prairie dog prey base fell victim to two different disease epizootics (Forrest et al. 1988, Thorne and Williams 1988, Williams et al. 1988, Clark 1989), there was no increase in the percentage of articles on diseases.

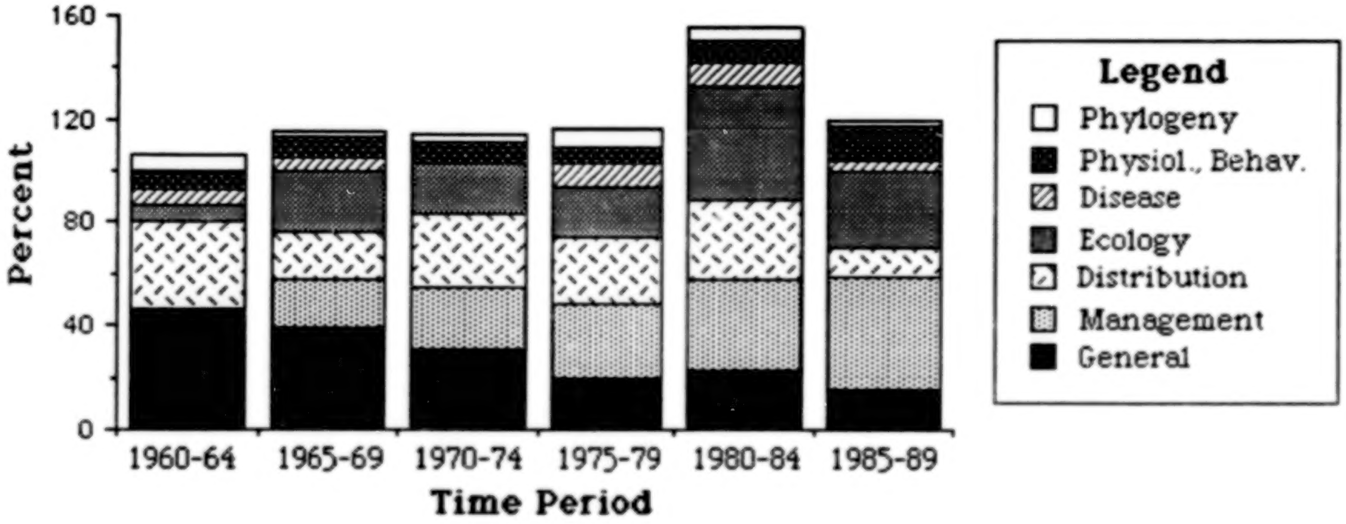

Figure 1. Subject matter of articles over time expressed as a percentage of the total number of articles published (Note: an article may cover more than one subject, thus percentages add to over 100).

Interest in and awareness of the plight of endangered species increased dramatically during the environmental movement of the 1960s and 1970s (Dunlap 1988). As interest grew, so did the size and number of non-governmental organizations working toward endangered species conservation (Tober 1989). In addition, the resultant legislation required increased governmental agency involvement, leading to greater numbers of government employees responsible for the conservation and management of endangered wildlife (Bean 1983). The number of both articles published and authors publishing articles on endangered species would therefore be expected to increase since 1960. This was the case for BFFs.

The literature on black-footed ferrets increased geometrically over time (Fig. 2A; Casey et al. 1986). Two large increases in the number of publications coincided with the discovery of the only two populations of ferrets studied — Mellette County, SD, in 1964 and Meeteetse, WY, in 1981 (Fig. 2A). Interestingly, while the number of publications dropped after extinction of the Mellette County population in 1974 (Fig. 2A), following the outbreak of canine distemper in the Meeteetse population in 1985 there was a large increase in number of publications (Fig. 2B). The number of publications per year has remained relatively high during the last 5 years (Fig. 2B). Management of the Meeteetse BFFs was more highly publicized than the management of the Mellette County population; primarily due to increased public interest in endangered species, but also because ferrets were thought to be extinct by many people prior to discovery of the Meeteetse population. Greater interest in, and involvement with, BFF management led to closer scrutiny of, and a wider array of perspectives on, the BFF management program.

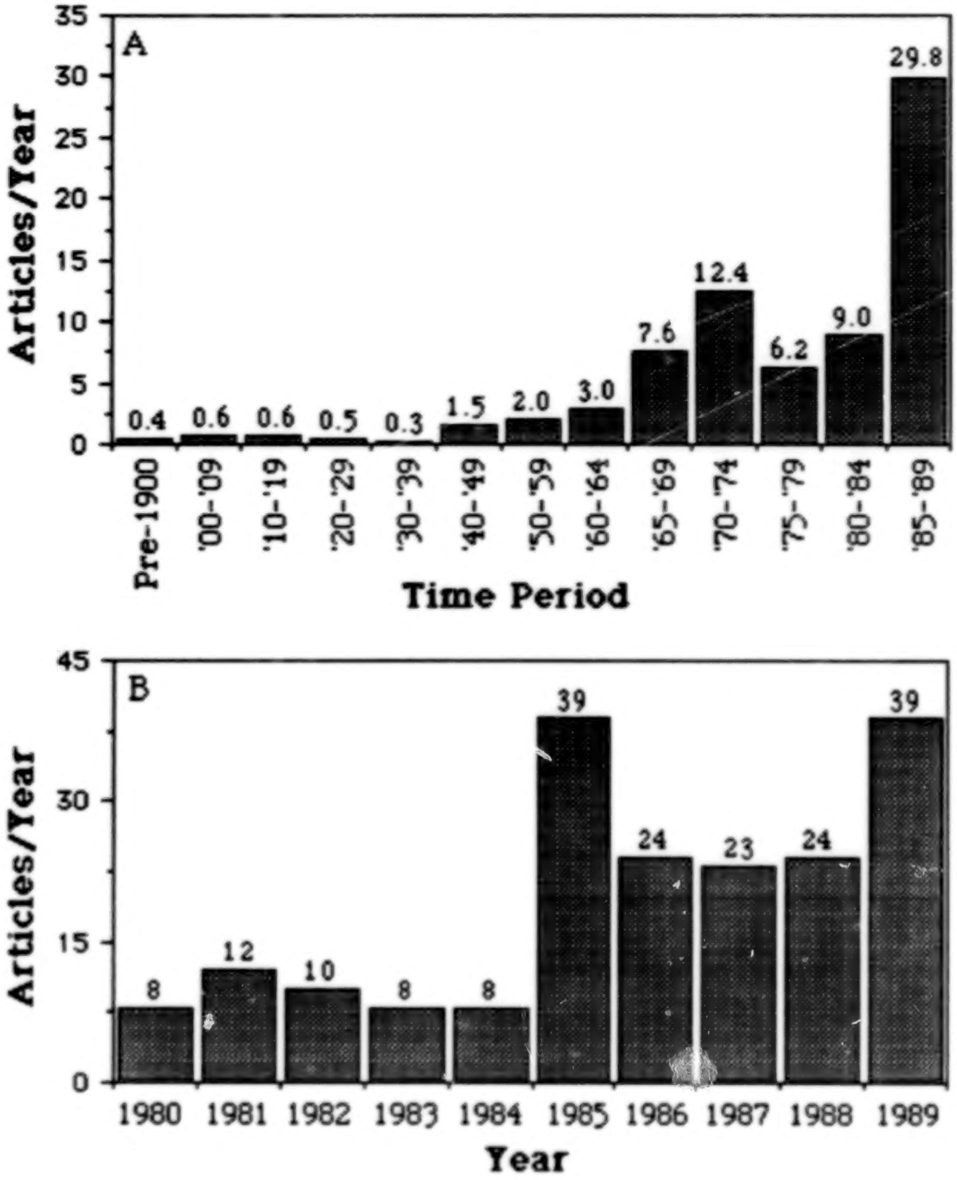

Figure 2. Number of articles published per year for all years (A) and from 1980 to 1989 (B).

Several trends in authorship were apparent. The mean number of authors per article increased over time (Fig. 3A), as did the total number of authors publishing (Fig. 3B). The former suggests increased collaboration among researchers, while the latter indicates both an increased interest in BFFs and an increase in the number of BFF researchers and managers. Trends in total number of authors, as with the trends in number of articles published, paralleled events in BFF conservation. The number of authors increased following discovery and research on the only two populations of BFFs ever studied in 1964 and 1981 (Fig. 3B).

Trends were also apparent in primary author affiliation (Fig. 4). An analysis of author affiliation provides an indication of the range of organizations involved in BFF conservation efforts and their relative contribution. Federal government employees and people affiliated with universities published a majority of the BFF articles in the 1960s. By the early 1970s, there was an increase in authors affiliated with state governments and conservation or research organizations. Overall, the percentage of government employed authors remained about the same, but there was a shift away from primarily federal employees and toward an increasing percentage of state employee authors. The percentage of authors affiliated with universities decreased from 1960 to 1989, while there was a substantial increase in the percentage of articles published by authors from non-governmental research and conservation organizations. This reflects the growing involvement of these latter organizations in endangered species research and management.

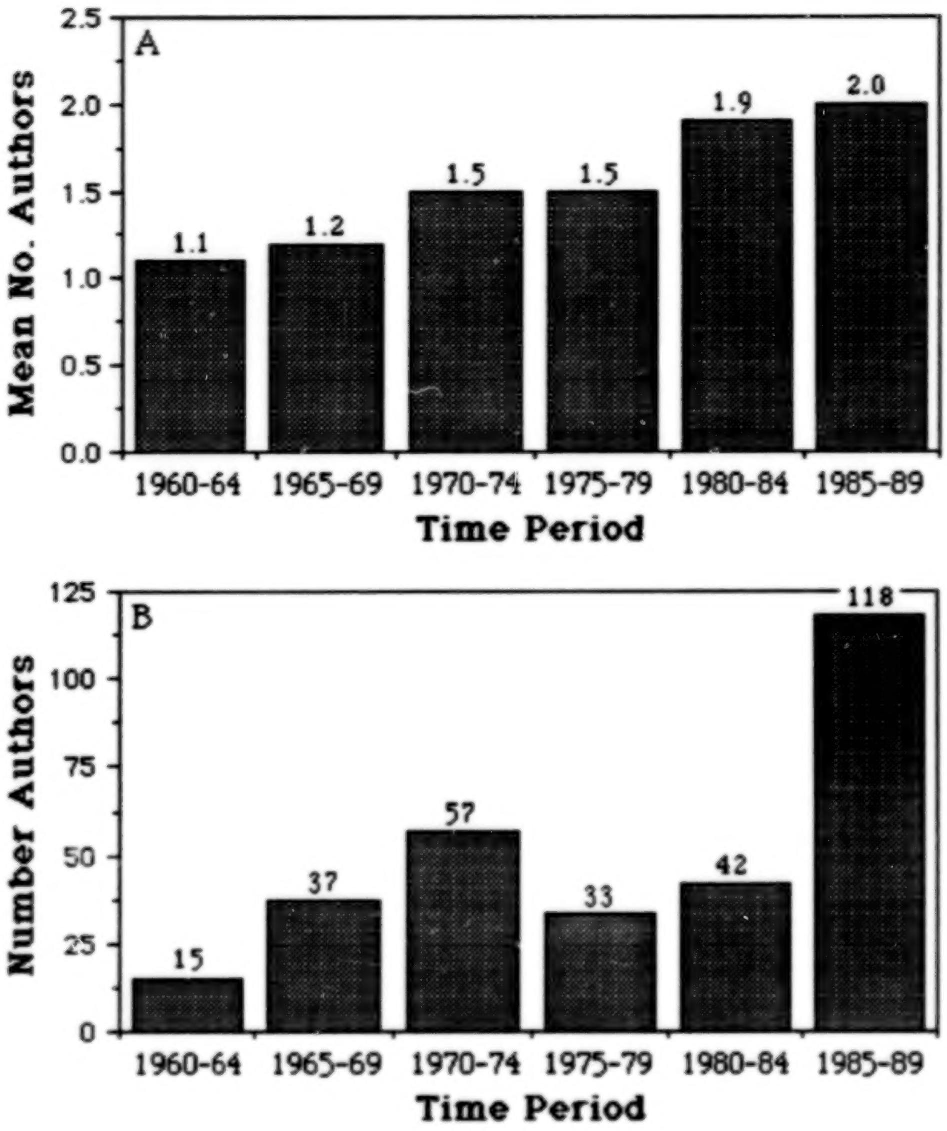

Figure 3. Trends in authorship. A. Mean number of authors/article. B. Total number of authors publishing during each five year time period.

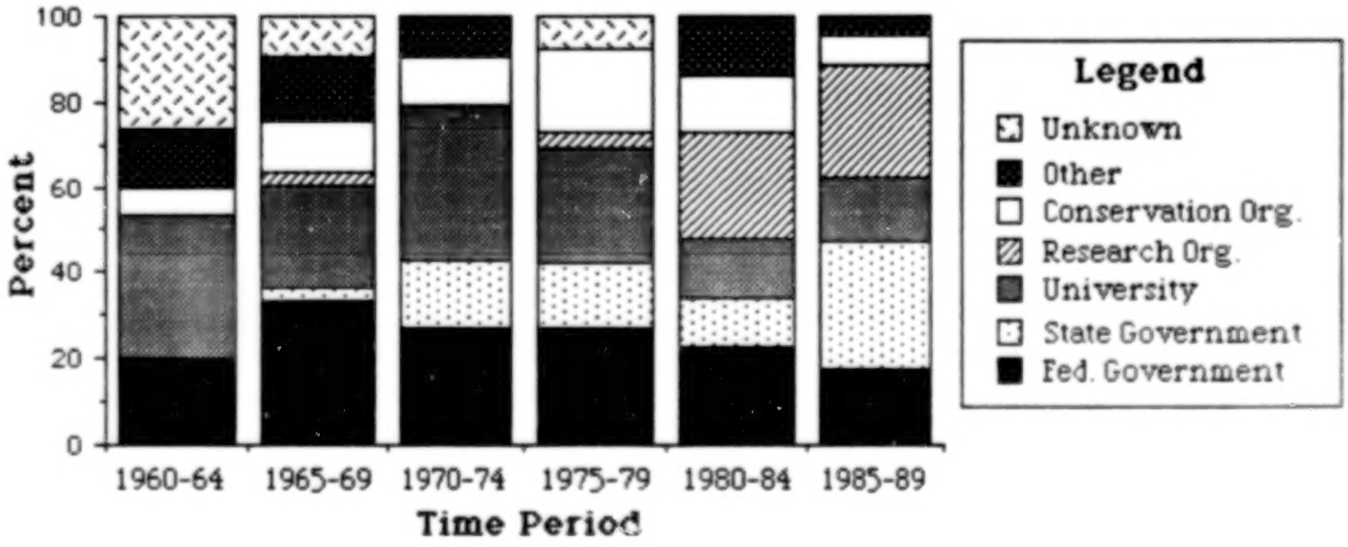

Figure 4. Change in primary author affiliation over time expressed as a percentage of the total number of article published.

CONCLUSIONS

Several trends in BFF publications are apparent. Paper topics have moved from general species accounts and descriptions to more technical biological and ecological reports to management issues. The number of articles published each year has increased over time, as has the number of publishing authors and number of authors per article. Primary author affiliations have become more diverse, with increasing contributions from members of state governments and non-governmental research and conservation organizations. These trends reflect the growing interest in BFF conservation and management, which, in turn, parallels the increasing concern for endangered species over the last few decades.

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Articles include in this bibliography are categorized as follows:

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Casey, D.E., J. DuWaldt, and T.W. Clark. 1986. Annotated bibliography of the black-footed ferret. Gr. Basin Nat. Mem. 8:185-208.

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Clark, T.W., 1989. Conservation biology of the black-footed ferret, *Mustela nigripes*. Wildlife Preservation Trust International, Philadelphia. Special Scientific Rept. No. 3:1-175.

Clark, T.W., D. Hinckley, and T. Rich, eds. 1989. The prairie dog ecosystem: managing for biological diversity. Montana Bureau of Land Management, Billings. Montana BLM Wildlife Technical Bulletin 2:1-55.

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Forrest, S.C., D.E. Biggins, L. Richardson, T.W. Clark, T.M. Campbell III, K.A. Fagerstone, and E.T. Thorne. 1988. Population attributes for the black-footed ferret (*Mustela nigripes*) at Meeteetse, Wyoming, 1981-1985. J. Mamm. 69:261-273.

Thorne, E.T., and E. Williams. 1988. Diseases and endangered species: The black-footed ferret as a recent example. Conserv. Biol. 2:66-73.

Tober, J.A., 1989. Wildlife and the public interest: Non-profit organizations and federal wildlife policy. Praeger Publishers, NY 220 pp.

Williams, E.S., E.T. Thorne, M.J.G. Appel, and D.W. Belitsky. 1988. Canine distemper in black-footed ferrets (*Mustela nigripes*) from Wyoming. J. Wildl. Diseases 24:387-398.

BLACK-FOOTED FERRET ANNOTATED BIBLIOGRAPHY, 1986-1990

1. **Abbate, D., J.P. Ward, and S. Anderson. 1988. Plague survey results: Meeteetse and Shirley Basin. Completion Report, April 15, 1987 to April 14, 198. Pp. 62-73, *in* Endangered and Nongame Bird and Mammal Investigations, Annual Completion Report, April 15, 1987 to April 14, 1988. Wyoming Game and Fish Department.**

Flea population monitoring of the Meeteetse, Wyoming, black-footed ferret research area initiated during 1986 was continued in 1987. Analysis for the presence of plague (*Yersinia pestis*) in the Meeteetse area resulted in 6 positive diagnoses representing approximately 2/3 of the research area. While 9 flea species were identified, only 4 species tested positive for plague. The results appear to indicate plague is widespread in the Meeteetse complex. At the Shirley Basin site, prairie dog towns were sampled twice. Fleas from one town tested positive for plague during the second sampling. The number of fleas and the number of flea species was less than in Meeteetse, which may be attributed to bias in collection methods.

2. **Anderson, E. 1989. The phylogeny of mustelids and the systematics of ferrets. Pp. 10-20, *in* U.S. Seal, E.T. Thorne, M.A. Bogan, and S.H. Anderson (eds.). Conservation biology of the black-footed ferret. Yale University Press, New Haven, CT.**

This chapter briefly traces the fossil history of the Mustelidae and discusses the subfamilies of the Mustelidae, the genus *Mustela*, the subgenera of *Mustela*, and especially the subgenus *Putorius*, the ferrets.

3. **Anonymous. 1990. Matador Ranch proves environment and agriculture are one in the same. National Woolgrower April:19, 22.**

Brief popular article discussing sheep management on the Matador Ranch in Phillips County, MT, and the possible repercussions of black-footed ferret reintroduction to the ranch.

4. **Ballou, J.D. 1989. Inbreeding and outbreeding depression in captive propagation of black-footed ferrets. Pp. 49-68, *in* U.S. Seal, E.T. Thorne, M.A. Bogan, and S.H. Anderson (eds.). Conservation biology of the black-footed ferret. Yale University Press, New Haven, CT.**

This chapter discusses two genetic considerations important to the survival of the captive ferret population: inbreeding and outbreeding depression. Because both could significantly affect survival and reproduction in other captive populations, they should be addressed in the development of a black-footed ferret captive-breeding plan.

5. **Ballou, J.D., and B. Oakleaf. 1989. Demographic and genetic captive-breeding recommendations for black-footed ferrets. Pp. 247-267, *in* U.S. Seal, E.T. Thorne, M.A. Bogan, and S.H. Anderson (eds.). Conservation biology of the black-footed ferret. Yale University Press, New Haven, CT.**

In August 1986, the Captive Breeding Specialist Group of the IUCN met in Laramie, Wyoming, with personnel of the Wyoming Game and Fish Department and the U.S. Fish and Wildlife Service to discuss a management plan for the captive population of black-footed ferrets at Sybille, Wyoming. The plan was to address the genetic and demographic management of the captive animals as a population and to take as a priority the long-term preservation of the black-footed ferret as a species. This chapter details the recommendations that came out of that meeting, one of which was a detailed propagation plan.

6. **Biggins, D., and R.A. Crete. 1989. Black-footed ferret recovery. Pp. 59-63, *in* A.J. Bjugstad, D.W. Uresk, and R.H. Hamre (Technical Coordinators). Ninth Great Plains wildlife damage control workshop, April 17-20, 1989, Fort Collins, CO. General Technical Report RM-171. U.S.D.A. Forest Service, Rocky Mountain Forest and Range Experimental Station, Fort Collins, CO.**

The captive population of black-footed ferrets (Mustela nigripes) increased from 24 to 58 animals in 1988, and was split to provide the species added protection against extinction. Experimental reintroductions may begin in 1991. In some areas, "experimental population" designations as authorized under Section 10(j) of the Endangered Species Act may be used to provide wider management latitude. The Black-footed Ferret Interstate Coordinating Committee oversees much of the work related to reintroduction. Expanded effort to locate wild ferrets now includes a $10,000 reward offer. Research focuses on captive breeding reintroduction techniques, disease, and habitat. A new Recovery Plan was approved in 1988.

7. **Biggins, D.E., and R.M. Engeman. 1986. Aerial survey or black-footed ferret sign in snow. Pp. W-7.2, *in* Abstracts for Contributed Papers, Thirteenth International Biometric Conference, Seattle, WA. Biometric Society Publication.**

Searches for black-footed ferret (BFF) sign in snow constitute a search for rare events because few individuals remain in the wild and BFFs are estimated to produce detectable sign less than 40% of the nights when adequate snow conditions exist. Ground (foot) searches for sign are labor intensive (32 ha/hr) and costly ($0.31/ha) with drawbacks that probability of observing sign may decrease with time and marginal habitats are not covered. These considerations motivated experimentation with aerial searches. Intensities of 3000 ha/hr and 6000 ha/hr cost $0.09/ha and $0.07/ha, respectively. Sign detection probability appears not to decrease with time and the detection probability for diggings is nearly 100%. The diminished BFF population and mild winter did not allow adequate comparative studies of aerial and foot searches; however, the initial results of aerial and foot searches compare favorably. For larger BFF populations, aerial searches for tracks may be used for population estimation with size biased sampling.

8. **Biggins, D., B. Miller, B. Oakleaf, A. Farmer, R. Crete, and A. Dood. 1989. A system for evaluating black-footed ferret habitat. Report Prepared for the Black-Footed Ferret Interstate Coordinating Committee. U.S. Fish and Wildlife Service, 1300 Blue Spruce Drive, Fort Collins, CO. 25 pp.**

We have attempted to provide a practical system for evaluating black-footed ferret habitat, including its biotic and abiotic components. The system is primarily designed for comparing potential reintroduction sites, but it may also aid in ranking areas to be searched for surviving ferret populations. Imperfections remain in the strategy, but we are confident that it will separate complexes with major differences. The model of ferret-prairie dog relationships should prove useful to estimate numbers of reproducing ferrets a complex can support. Attributes other than prey base, however, may also be important and influence a decision. Because subjectivity cannot be removed from the process, we must rely heavily on collective "expert opinions" in the final analysis.

9. **Biggins, D., and M.H. Schroeder. 1988. Historical and present status of the black-footed ferret. Pp. 93-97, *in* D.W. Uresk, G.L. Schenbeck, and R. Cefkin (Technical Coordinators). Eighth Great Plains wildlife damage control workshop proceedings, April 28-30, 1987, Rapid City, SD. General Technical Report RM-154. U.S.D.A. Forest Service, Rocky Mountain Forest and Range Experimental Station, Fort Collins, CO.**

The black-footed ferret was once widely distributed in the Great Plains and intermountain valleys of North America, its range overlapping the combined ranges of several species of prairie dogs. Most life history information has been obtained from studies of ferrets in southwestern South Dakota (1964-1974) and studies near Meeteetse, Wyoming (1981-present). The ferret's nearly complete dependence on prairie dogs was documented in both study areas. The recent collapse of the Meeteetse population of ferrets due to an outbreak of canine distemper underscores the threat posed by this disease, but reductions of prairie dogs by man and other diseases are also potentially harmful. Eighteen animals are being held for captive breeding, no free-ranging ferrets have been located, and species recovery seems dependent on captive propagation and releases.

10. **Brussard, P.F., and M.E. Gilpin. 1989. Demographic and genetic problems of small populations. Pp. 37-48, *in* U.S. Seal, E.T. Thorne, M.A. Bogan, and S.H. Anderson (eds.). Conservation biology of the black-footed ferret. Yale University Press, New Haven, CT.**

In general, rare, threatened, or endangered species have populations that either are sparsely distributed over a large area or exist as small groups in one or a few particular spots; both cases involve small numbers of animals. Population biologists have only recently become interested in the problems of small or fragmented populations, primarily in response to the needs of various government agencies charged with preserving biological diversity. This chapter summarizes our current understanding of the demographic and genetic problems encountered by small populations, using the black-footed ferret as an example whenever possible.

11. **Campbell, T.M. III. 1989. Prairie dog colony location surveys and black-footed ferret searches in Montana. Pp. 1-12 *in* T.W. Clark, D. Hinckley, & T. Rich (eds.) The prairie dog ecosystem: managing for biodiversity. Montana Bureau of Land Management Wildlife Technical Bulletin 2.**

Searches to locate black-footed ferret (*Mustela nigripes*) populations and their potential habitat represented by prairie dog (*Cynomys* spp.) colonies were conducted in Montana between 1984 and 1989. The locations of 700+ prairie dog colonies totalling more than 100,000 ac (~40,500 ha) were discovered with about 77% comprising 8 general concentration areas. Sightings of black-footed ferrets were solicited from the public by appealing to their interests (Pre-Reward Program) and by monetary incentives (Reward Program). Only one report was confirmed to have involved a live black-footed ferret. The finding of one ferret cranium from Fort Belknap Indian Reservation was documented. Five specific areas were identified as having relatively high potential of supporting black-footed ferret populations. These areas, which represented about 34,500 ac (~14,000 ha), were searched employing nocturnal summer and/or diurnal winter surveys for a total of 170 person days. Additionally, numerous short-term ferret searches totalling 50 person days were conducted statewide on about 7,000 ac (2,832 ha) of colonies. Searches produced no evidence of current ferret presence but yielded skeletal material from 2 individual ferrets in Carter County on the same 2,500 ac (1,011 ha) colony which produced the confirmed ferret sighting.

12. **Campbell, T.M., III., T.W. Clark, L. Richardson, S.C. Forrest, and B.R. Houston. 1987. Food habits of Wyoming black-footed ferrets. American Midland Naturalist 117:208-210.**

Eighty-six scats were analyzed to determine food habits of wild black-footed ferrets (*Mustela nigripes*). Most scats were collected during winter (N=27) and spring (N=27); scats from summer (N=2), autumn (N=2) and from undetermined seasons (N=28) accounted for the remainder. White-tailed prairie dog remains occurred in 87% of all scats. Mouse remains were found in 6% and lagomorph remains in 3% of scats.

13. **Carlson, J. 1989. North-central Montana: Biological evaluation for potential black-footed ferret reintroduction. Unpublished report to the Montana Black-Footed Ferret Working Group and the Black-Footed Ferret Interstate Coordinating Committee. Federal Building, U.S. Fish and Wildlife Service, Helena, MT. 9 pp.**

This report analyzes potential black-footed ferret habitat in northcentral Montana. It examines 2 scenarios: one involving a portion of the area that was sampled for prairie dog density and a second which extrapolates from the data obtained in scenario 1 to include additional federal, state, private, and Indian lands. The Scenario 1 complex, which includes 122 prairie dog towns covering 8350 acres, could theoretically support about 230 ferret families. The 38,960 acres of prairie dog colonies in the Scenario 2 complex, which includes all towns within the "7 km rule," could theoretically support about 466 ferret families. Additional biological factors are also considered.

14. **Carr, A., III. 1986. Perspective: Ferret foul-up. Animal Kingdom 89(3):44-47.**

Popular article summarizing the events at Meeteetse, Wyoming, from the discovery of black-footed ferrets until their demise due to an outbreak of canine distemper. The article criticizes agency management and suggests that the U.S. Endangered Species Act is fundamentally flawed.

15. **Clark, T.W. 1986a. Black-footed ferrets on the edge. Endangered Species Technical Bulletin Reprint 3(7):1-4.**

Overview of black-footed ferret conservation efforts through early 1986. The article briefly covers the history of ferret decline, especially in Meeteetse, Wyoming; past and recent research findings pertinent to ferret management; and future recovery potential and conservation options.

16. **Clark, T.W. 1986b. Black-footed ferret: ghost of the prairie. Animal Kingdom 89(3):38-43,48.**

Popular account of black-footed ferrets in Meeteetse, Wyoming. The article discusses the events which led to discovery of the Meeteetse population, research efforts and findings, and the decline of the population following the catastrophic outbreak of canine distemper in 1985.

17. Clark, T.W. 1986c. Annotated prairie dog bibliography, 1973-1985. Montana Bureau of Land Management Wildlife Technical Bulletin 1:1-32.

This annotated bibliography takes up where the only two previously produced ones left off, beginning with the literature in 1973 and ending in 1985. Nearly all of the citations are from published literature. Abstracts, highlights, synopses, or summaries are listed for most entries. The 201 citations are categorized by subject. Much of the scientific basis for enhanced prairie dog management is derived from the references included in this bibliography. This bibliography can serve land wildlife managers with an up-to-date, easily accessible description of the scientific literature on prairie dogs printed in the last 13 years.

18. Clark, T.W. 1987a. Black-footed ferret recovery: a progress report. Conservation Biology 1:8-11.

A brief historical review of black-footed ferret recovery efforts. The article focuses on the Meeteetse population, describing significant events through the Fall of 1986.

19. Clark, T.W. 1987b. Restoring balance between the endangered black-footed ferret (*Mustela nigripes*) and human use of the Great Plains and intermountain west. Journal of the Washington Academy of Science 77:168-173.

Ferrets were directly and indirectly reduced from a 100 million acre range in about 1900 to less than 7,000 acres by 1981 (99.9 + % reduction) by habitat loss and possibly other factors. Recent work (1981-1986) near Meeteetse, Wyoming, the site of the only known wild population, and searches elsewhere for more ferrets are described. The small Meeteetse population (peak number 129 in 1984) suffered a catastrophic die-off in 1985 from disease. The last 18 ferrets were taken into captivity for breeding. In 1987, two litters were born. Several sites to return ferrets to the wild are being prepared. There is every reason to believe ferrets will eventually be recovered, thus restoring the balance between this species and human uses of the Great Plains and the intermountain West.

20. Clark, T.W. 1989. Conservation biology of the endangered black-footed ferret (*Mustela nigripes*). Wildlife Preservation Trust International Special Scientific Report 3:1-175.

Conservation research and recovery efforts on the Meeteetse black-footed ferrets from 1981 through early 1988 are the subjects of this account. If ferret recovery is to be achieved, three interactive challenges - biological, socioeconomic, and organization and management - must be addressed simultaneously and successfully. Each of the three challenges are discussed in depth. Biological work focused on a population viability assessment of the Meeteetse ferrets and required knowledge about ferret: 1) history, systematics and biogeography; 2) demographics; 3) population genetics; 4) environmental and habitat relationships; and 5) behavior and activity patterns. The socioeconomic challenge to ferret conservation and recovery focused on the Meeteetse area's human culture and compatibility of ferret habitat needs with oil and gas extraction in the region. The organization and management challenge - designing and managing the programs needed to carry out ferret recovery successfully - is recognized as a major variable in endangered species recovery which either facilitates or hinders workers in meeting objectives. This account was written not only to describe ferret conservation and recovery, but also to encourage more concentrated effort on many other endangered species and especially on the ecosystems of which they are a part.

21. Clark, T.W., J. Grensten, M. Gorges, R. Crete, and J. Gill. 1987. Analysis of black-footed ferret translocation sites in Montana. Prairie Naturalist 19:43-56.

Recovery of the critically endangered black-footed ferret (*Mustela nigripes*) requires establishing several secure populations over a multistate area. Eastern Montana was searched (1982-1986) for remnant ferret populations and for potential transplant sites (i.e., black-tailed prairie dog, *Cynomys* spp. colonies). No live ferrets were seen, but skeletal remains of three ferrets were found. Eight major "complexes," or clusters of colonies, totaling 13,412 ha in 179 colonies, were examined and described. Using a habitat suitability index model, they were compared to each other and to the Meeteetse, WY, and Mellette

County, SD, ferret/prairie dog areas. Five of the complexes represented high quality potential ferret habitat, while the other three were of intermediate value. The largest complex was 53 colonies, 3147 ha, mean colony size 59 ha. The "habitat patch" and "metapopulation" concepts are discussed in terms of ferret recovery and management. Multiple use land management in ferret reintroduction area is expected to continue.

22. Clark, T.W., and A.H. Harvey. 1988. Implementing endangered species recovery policy: Learning as we go? Endangered Species UPDATE 5(10):35-42.

Professionals working in endangered species recovery programs often view recovery primarily as a biological problem. They have generally given much less explicit attention to policy and organizational variables. Yet the organizational arrangements, decision-making processes, and other policy variables affecting recovery programs can be as critical to success as technical and biological tools. This paper discusses four common features of recovery programs that have led to implementation problems. First, species recovery is a tremendously complicated task, often involving numerous participants who must somehow integrate their diverse perspectives into a workable program. Second, these participants often have conflicting goals. Third, explicit consideration of organizational structures appropriate to the task of saving species is rare. Fourth, intelligence failures and program delays often occur. To illustrate these points, examples are drawn from the ongoing black-footed ferret recovery effort. The second section of the paper suggests ways to improve the policy, organizational, and individual dimensions of recovery program implementation.

23. Clark, T.W., D. Hinckley, and T. Rich (eds.). 1989. The prairie dog ecosystem: Managing for biological diversity. Montana Bureau of Land Management Wildlife Technical Bulletin Number 2. Bureau of Land Management, State Office, Billings, MT. 55 pp.

The prairie dog ecosystem is that assemblage of species and ecological processes associated with prairie dog colonies. Over 100 vertebrate species are known to use prairie dog colonies as habitat. Some of these species are nearly totally dependent on prairie dogs, such as black-footed ferrets; others clearly benefit from their relationship, such as the ferruginous hawk; and still others are minimally associated, such as the horned lark. This biological diversity includes a variety of predator-prey relationships and competitive interactions. Management for the maintenance of biological diversity in the prairie dog ecosystem will depend on adequate research about this complex of species and their environmental relationships. This volume was prepared to support this goal - management for the conservation of biological diversity of the prairie dog ecosystem.

24. Clark, T.W., and R. Westrum. 1987. Paradigms and ferrets. Journal of Social Studies in Science 17:3-34.

Protecting endangered species is a very complicated scientific task, requiring ingenuity and imagination. Yet the organizations to which we have given this task may be little suited to it. Examining the ecology of black-footed ferrets and their near-extinction under government management, the authors question the adequacy of traditional wildlife management approaches whose calculative rationality fails to respond to the often rapidly changing and precarious situation of an endangered species. They argue that a different, generatively rational approach is needed if species like the ferret are to survive. Such an approach would use available cognitive resources better than does the highly centralized approach which wildlife bureaucracies seem to favour. Such organizational checks and balances would provide less danger for blind spots in our perception of the environment.

25. Clark, T.W., and R. Westrum. 1989. High performance teams in wildlife conservation: A species reintroduction and recovery example. Environmental Management 13:663-670

Reintroduction of animals to the wild to establish free-ranging viable populations is a valuable conservation tool. But ecological skills alone are not enough to ensure a successful reintroduction; also needed to do the work are effectively designed and managed programs. This paper suggests general guidelines for organizing and managing reintroduction programs, reviews some basic organizational issues, and considers ways to develop high performance teams. The need to integrate reintroduction programs into their larger interorganizational context is discussed. The reintroduction program's structure must be appropriate for its function and should be properly staffed, led, and buffered from its political environment. It should process information well, learn rapidly from its own mistakes, and be creative. A high performance team devotes most of its energies to solving external rather than internal problems.

26. Cole, B.P. 1989. Recovery planning for endangered and threatened species. Pp. 201-209, *in* U.S. Seal, E.T. Thorne, M.A. Bogan, and S.H. Anderson (eds.). Conservation biology of the black-footed ferret. Yale University Press, New Haven, CT.

The Endangered Species Act as amended in 1982 directs the secretaries of interior and commerce to develop a list of species that are in danger of extinction and to carry out programs for the conservation of listed species. This chapter discusses the listing and recovery process and briefly describes the U.S. Fish and Wildlife Service's black-footed ferret recovery efforts.

27. Cully, J.F., Jr. 1989. Plague in prairie dog ecosystems: Importance for black-footed ferret management. Pp. 47-55 *in* T.W. Clark, D. Hinckley, & T. Rich (eds.) The prairie dog ecosystem: managing for biodiversity. Montana Bureau of Land Management Wildlife Technical Bulletin 2.

Prairie dog numbers and the area covered by their colonies in the western United States declined drastically between 1900 and 1970 as a result of government pest control and probably plague epizootics. Concomitant with the reduction in area of prairie dog colonies, the black-footed ferret (*Mustela nigripes*), which depends on prairie dogs for prey and their burrows for shelter, also disappeared from most of its former range. Because of the ferret's dependence on prairie dogs, plague epizootics in prairie dog colonies are a serious problem for ferret management. In this paper the plague literature, as it pertains to prairie dogs, is reviewed. Known differences between the response of different prairie dog species' to plague are described, and several areas where future research might provide insights useful for prairie dog management are explored. The most important basic research questions for management of the prairie dog plague ecosystem are: (1) how is plague maintained in the prairie dog ecosystem between epizootics, and (2) how are plague epizootics in prairie dog colonies started? Answers to these related questions should help to decide where ferret reintroductions are most likely to be successful, and make it possible to predict when plague epizootics in particular prairie dog colonies are likely to begin.

28. Dierenfeld, E. 1987. Black-footed ferret diet review. Unpublished Report, New York Zoological Society (Bronx Zoo), Bronx, NY, to International Union for Conservation of Nature and Natural Resources, Captive Breeding Specialist Group, Minneapolis, MN. 11 pp.

A detailed dietary review of domestic ferrets (*Mustela putorius furo*), Siberian polecats (*M. eversmanni*), and black-footed ferrets (*M. nigripes*). The report discusses dietary requirements, the nutritional composition of current diets, and recommendations for dietary changes and food handling, storage, and preparation.

29. DonCarlos, M.W., and J. Doherty. 1987. 1988. Black-footed ferret captive breeding management plan. Unpublished Report to International Union for Conservation of Nature and Natural Resources, Captive Breeding Specialist Group, Minneapolis, MN. 4 pp.

30. DonCarlos, M.W., B. Miller, and E.T. Thorne. 1989. The 1986 black-footed ferret captive breeding program. Pp. 235-246, *in* U.S. Seal, E.T. Thorne, M.A. Bogan, and S.H. Anderson (eds.). Conservation biology of the black-footed ferret. Yale University Press, New Haven, CT.

Six black-footed ferrets (*Mustela nigripes*), including two juvenile (<1 yr.) males, one juvenile female, and three parous adult females were managed in captivity during the 1986 breeding season. Breeding introductions (N=99) were conducted and recorded on videotape. Two copulations were observed, but no offspring resulted. Black-footed ferret reproductive behaviors, including female solicitation and copulation, are defined and described. Reproductive behaviors for other wild mustelid species are discussed, and compared to those of black-footed ferrets. Factors contributing to the lack of success in black-footed ferret captive breeding in 1986 are discussed.

31. Fagerstone, K.S., and B.E. Johns. 1987. Transponders as permanent identification markers for domestic ferrets, black-footed ferrets, and other wildlife. Journal of Wildlife Management 51:294-297.

A 0.05-g transponder implanted subcutaneously was tested to see if it provided a reliable identification method In laboratory tests 20 domestic ferrets (*Mustela putorius furo*) received transponders and were monitored for a minimum of 6 months. None showed signs of inflammation, and necropsies conducted at the end of the study showed no scar tissue or transponder migration. Seven of 23 transponders failed during the test because of leakage through the plastic case, and a glass case is now being manufactured that does not have the leakage problem. During mark-recapture studies in September and October 1985, transponders were implanted in 20 black-footed ferrets (*M. nigripes*), 11 of which were subsequently recaptured and 9 of which were brought into captivity; none showed signs of inflammation. Transponders provide a reliable new method for identifying hard-to-mark wildlife with a unique, permanent number that can be read with the animal in-hand or by remote equipment.

32. Flath, D. 1987. Wanted: The masked stranger. Montana Outdoors 18(4):18-22.

Popular article discussing efforts to locate black-footed ferrets and potential ferret habitat in Montana. The article also briefly discusses the events surrounding the demise of the Meeteetse, WY, population of ferrets.

33. Flath, D., and T.W. Clark. 1989. America's most endangered mammal: The effort to save the black-footed ferret. Bison 5:18-23.

Popular article discussing the plight of the black-footed ferret. It focuses on the events and management of the Meeteetse, Wyoming, population from its discovery until mid-1988. It also briefly discusses ferret conservation efforts in Montana.

34. Flesness, N.R. 1989. Mammalian extinction rates: background to the black-footed ferret drama. Pp. 3-9, *in* U.S. Seal, E.T. Thorne, M.A. Bogan, and S.H. Anderson (eds.). Conservation biology of the black-footed ferret. Yale University Press, New Haven, CT.

Population estimates indicate that the black-footed ferret is having a very close brush with extinction. Their fate should be seen in a broader context. Species have always been going extinct, but the current rate is far above normal. Human activities have greatly speeded up extinctions. This chapter compares current and historic extinction rates and briefly describes the endangerment of the black-footed ferret.

35. Foose, T.J. 1989. Species Survival Plans: the role of captive propagation in conservation strategies. Pp. 210-222, *in* U.S. Seal, E.T. Thorne, M.A. Bogan, and S.H. Anderson (eds.). Conservation biology of the black-footed ferret. Yale University Press, New Haven, CT.

Conservation strategies traditionally have placed primary attention on protection of natural habitats and, by extension, of their resident populations. Such actions may not be sufficient, however, where degradation of habitat has greatly reduced and fragmented natural populations. Moreover, many wildlife species are decimated even before other elements of their natural habitat. In either case, the resultant small, wild populations become vulnerable to and possibly extinct by genetic and demographic problems. As a consequence, species survival plans (SSPs) must be predicated on population biology and management. The objective of SSPs is the preservation of wildlife as both species and as constituents of their ecosystems. Thus, SSPs deal with both captive and wild populations. Finally, there are both biological and organizational components to SSPs. This chapter discusses these aspects, with special reference to SSPs being developed with the involvement of the zoo community, and in relation to the black-footed ferret.

36. Forrest, S.C., D.E. Biggins, L.Richardson, T.W. Clark, T.M. Campbell, III, K.A. Fagerstone, and E.T. Thorne. 1988. Population attributes for the black-footed ferret (*Mustela nigripes*) at Meeteetse, Wyoming, 1981-1985. Journal of Mammalogy 69(2):261-273.

Numbers of adults and juveniles in the single known free-ranging population of the endangered black-footed ferret (*Mustela nigripes*) at Meeteetse, Wyoming, were estimated annually in July from spotlighting as 88 (1983), 129 (1984), and 59 (1986). Population sizes in September, determined from mark-recapture studies, were 128 +- 25(1984) and 31+- 8 (1985). Lower population estimates in 1985 reflected, at least in part, an ongoing epizootic of canine distemper in ferrets that decimated the population through November 1985, reducing it to ca. 6 individuals. From 1982 to 1985, adult sex ratio was 1 male:2.2 females; juvenile sex ratio (1 male:0.80 females) did not differ significantly from 1:1. The ratio of young to adults averaged 1.95:1 from 1982-1984 and 1.2:1 in 1985. At least 224 young were produced in 68 litters from 1982-1985, with a mean litter size a emergence of young of

3.3. Juvenile ferrets reached adult weight by September. Only one female tagged as a juvenile was recaught at 1 year of age, and she reproduced. Intercolony movements were primarily by juvenile males and occurred from September to October. Adults maintained geographic fidelity between years. Disappearance (mortality and emigration) rates ranged from 53 to 86% annually and were highest for juveniles. Observed ferret mortality in the absence of disease was primarily from predation. Reduction of the population during the epizootic suggests persistence of this population in the wild is unlikely.

37. Groves, C., and T.W. Clark. 1986. How many are enough? Bison 2(3):4-5.

Semi-technical article discussing conservation of the black-footed ferret. The article focuses on the minimum number of ferrets required to ensure survival of the species. It discusses threats to small populations and minimum viable population (MVP) concepts.

38. Hanebury, L., and D. Biggins. 1989. Black-footed ferret recovery update. Endangered Species Technical Bulletin 14(7):10.

Brief update of black-footed ferret recovery efforts. The article discusses inter-agency coordination efforts and recent attempts to locate wild ferrets.

39. Harris, R., T.W. Clark, and M. Shaffer. 1989. Extinction probabilities for black-footed ferrets. Pp. 69-82, *in* U.S. Seal, E.T. Thorne, M.A. Bogan, and S.H. Anderson (eds.). Conservation biology of the black-footed ferret. Yale University Press, New Haven, CT.

Black-footed ferrets, once widespread and relatively abundant, are today critically endangered. Restoration of the species to healthy numbers and distribution will require not only protection, but also knowledge of the probability of chance extinctions for isolated ferret populations of various sizes. Stochastic simulation models can be used to assess the viability of small populations. In this case we apply computer simulation to the problem of long-term management and reserve size by estimating probabilities of small ferret populations going extinct from demographic and environmental fluctuations. Our results suggest that ferret populations averaging 20 to 120 individuals will likely go extinct periodically within 100 years, even under total protection. Thus, maintenance of multiple, independent populations provides the best insurance against overall loss the species from chance extinction.

40. Joyce, S.L. 1988. Feeding behavior and water requirements of black-footed ferrets (*Mustela nigripes*). Unpublished M.S. Thesis, University of Wyoming, Laramie, WY. 82 pp.

Widespread poisoning of prairie dogs has been implicated in the near extinction of the black-footed ferret. To assess the risk of secondary poisoning, feeding behaviors of captive black-footed ferrets were studied. A technique using inert particle tracers was developed to investigate carcass use patterns by free-ranging animals. Water requirements of black-footed ferrets were studied as a potential influence on amount of prey consumed. Black-footed ferrets avoided gastrointestinal tracts of large prairie dogs, but did not avoid eating gastrointestinal tracts of smaller prey. Seasonal variation in prey intake of black-footed ferrets was also noted. A red particle tracer manufactured by Scientific Marking was found to be the most effective particle tracer and appears suitable for use in studying ingestion patterns of free-ranging animals. Results of water requirement studies suggest that black-footed ferrets are capable of renal water conservation during short-term water deprivation and that a water requirements variable should be added to prey requirements estimates, but additional studies need to be conducted to determine the magnitude of this variable.

41. Kinter, C.L., and B. Luce. 1989. Black-footed ferret surveys - Statewide. Completion Report, April 15, 1988 to April 14, 1989. Pp. 32-41, *in* Endangered and Nongame Bird and Mammal Investigations, Annual Completion Report, April 15, 1988 to April 14, 1989. Nongame Program, Biological Services Section, Wyoming Game and Fish Department.

Wyoming Game and Fish Department personnel received 65 reports of black-footed ferrets from mid-April 1988 to mid-March 1989. This represents a record number of reports over previous years. A poster and television campaign noting a $5,000 reward for information leading to the discovery of a ferret population undoubtedly increased the visibility of ferret searches. Telephone interviews were used to rank the sightings as probable (n=19), possible (n=27), or negative (n=19). The 46 reports classified as possible and probable, plus 8 reports received in past years but not pursued, were field checked in 1988. Prairie dog towns within 8 km of the sighting were mapped and designated active or inactive. No black-footed ferrets were located. All recorded ferret observations from 1970 through 1988 were plotted on a 1:500,000 scale state map and efforts were begun to compile a comprehensive list of all known ferret surveys in the state.

42. Kitchin, R.W., P.T. Curry, W. Borgess, M. Straley, M. Parker, and R.W. Atherton. 1988. Comparison of semen sperm content and sperm motility of European, Siberian, and black-footed ferrets. Journal of Andrology (Abstract) 9:P-40.

Semen samples were collected by electroejaculation from the European ferret (DF; *Mustela putorius*), the Siberian ferret (SIB-F;*M. eversmanni*), and the endangered black-footed ferret (BFF; *M. nigripes*). Fresh ejaculates were diluted in egg-yolk test extender and spermatozoa were recorded by videomicrography. Approximately 200 sperm/sample were classified subjectively as progressively motile, circularly motile, wiggling, or non-motile. X-Y coordinates were determined for at least 200 progressively motile sperm from each species over a two second interval (15 frames/sec) and six parameters of sperm motility were determined by computerized Autrack analysis (Tessler and Olds-Clarke, J. Androl. 6:35-44, 1985) of individual sperm tracks. Ejaculates of the BFF contained significantly fewer sperm (82 x 10^6/ml) than the DF (596 x 10^6/ml) or the SIB-F (624 x 10^6/ml). In the DF, 89% of the sperm were motile and over 70% exhibited progressive motility. In contrast, fewer than 25% of the sperm from BFF were motile; and only 10% of all sperm were progressively motile. The curvilinear velocity, an index of the sperm's mean swimming speed, was 116 u/sec in DF, 100 u/sec in SIB-F, and only 80 u/sec in BFF. The linearity index, a measure of the straightness of the sperm's trajectory, was approximately .80 in all three species.

43. Lacy, R., and T.W. Clark. 1989. Genetic variability in black-footed ferret populations: Past, present, and future. Pp. 83-103, *in* U.S. Seal, E.T. Thorne, M.A. Bogan, and S.H. Anderson (eds.). Conservation biology of the black-footed ferret. Yale University Press, New Haven, CT.

This chapter estimates effects of historical and recent declines in black-footed ferret numbers on genetic variability within the species. It also examines genetic variability within the surviving ferret population under several possible scenarios of demographic recovery. Understanding these genetic considerations is essential to ferret recovery planning and management.

44. Laing, R.I. 1986. The feasibility of reintroducing the black-footed ferret to the Canadian prairie. Unpublished Masters Project, University of Calgary. 134 pp.

The black-footed ferret is one of the most endangered species in North America. The recovery of the ferret will probably depend on successfully transplanting captive-born animals to suitable release sites.

The feasibility of re-introducing ferrets to an area in southern Saskatchewan was studied. This is the only area in Canada inhabited by prairie dogs, which are the preferred prey of black-footed ferrets. The proposed release site has been proposed to be established as a national park. The ferret's habitat requirements, release logistic concerns and competing land-use conflicts are examined.

A wild ferret release in Saskatchewan is not feasible at this time because of insufficient habitat and because ferrets are not immediately available from captive breeding. If prairie dog colonies can be expanded in Saskatchewan or increased in number, a future ferret release may be possible. To prepare for the possible future availability of black-footed ferrets, habitat enhancement techniques are presented.

Three alternative options to return ferrets to Canada, in addition to a wild release, are discussed. These include establishing a training center, a breeding facility and public display exhibits. A training facility could provide a feasible option for returning ferrets to Canada and contribute to the recovery of the black-footed ferret. A captive breeding facility could be feasible if funding for the project was established. Mobile live displays of ferrets are recommended for developing public awareness and support for the recovery of the black-footed ferrets.

45. Laing, R.I. 1987. An annotated bibliography: The black-footed ferret. Unpublished manuscript compiled for the Canadian Wildlife Service. 35 pp.

A compilation of 240 citations on black-footed ferrets through 1987. The listings are briefly annotated.

46. Laing, R.I., and G.L. Holroyd. 1989. The status of the black-footed ferret in Canada. Blue Jay 47:121-125.

Discussion of black-footed ferret historical records in Canada. The article notes a substantial number of reports from areas lacking prairie dogs and suggests ferrets may still exist in areas well beyond the range of black-tailed prairie dogs.

47. Lamerson, R.H., M. Butler, R. Van Kirk, and C. Voss. 1989. A viability assessment for an isolated black-footed ferret (*Mustela nigripes*) population at Meeteetse, Wyoming. Humbolt State University, Humbolt, CA. 61 pp.

This study employed a computer simulation model to investigate the viability of an isolated black-footed ferret population at Meeteetse, Wyoming. The model was fully stochastic and included details of BFF demography and life history, with particular attention given to the juvenile dispersal process. The actual prairie dog colony geography of the Meeteetse site was approximated in the simulation by use of a hexagonal grid, and dispersal was modeled by moving individuals in discrete steps on the grid. Simulations investigated the effects of demographic and environmental stochasticity, prairie dog colony distribution, dispersal success, and a canine distemper epizootic. Results supported six conclusions: 1) demographic stochasticity has little effect on population persistence except when population size is extremely small; 2) increased environmental stochasticity decreases population persistence substantially; 3) mean population size is much lower than the carrying capacity for the habitat; 4) extinction is more likely to occur when the number of occupied colonies becomes too low; 5) increase in dispersal mortality decreases population persistence; 6) introduction of canine distemper significantly reduces persistence only when several colonies are infected simultaneously. Secondary observations and management implications are also discussed.

48. Luce, B. 1989a. Black-footed ferret surveys - Meeteetse, Wyoming. Completion Report, April 15, 1987 to April 14, 1988. Pp. 28-31, *in* Endangered and Nongame Bird and Mammal Investigations, Annual Completion Report, April 15, 1988 to April 14, 1989. Nongame Program, Biological Services Section, Wyoming Game and Fish Department.

Intensive black-footed ferret surveys were conducted during May through September, 1987, to verify the status of the ferrets at Meeteetse. During 1466 hours (161 nights) of spotlight searching, no evidence of black-footed ferrets was observed in the entire Meeteetse Complex. Therefore, a much smaller search effort was put forth in 1988-1989. A total of 30 hours of ground searches and 4 hours of aerial searches revealed no evidence of black-footed ferrets in 1988-1989.

49. Luce, B. 1989b. State-wide black-footed ferret reintroduction analyses. Completion Report, April 15, 1988 to April 14, 1989. Pp. 42-43, *in* Endangered and Nongame Bird and Mammal Investigations, Annual Completion Report, April 15, 1988 to April 14, 1989. Nongame Program, Biological Services Section, Wyoming Game and Fish Department.

The University of Wyoming Cooperative Wildlife Research Unit conducted reintroduction site analyses on four sites in 1988 under contract with the Wyoming Game and Fish Department. On-site data collection varied from preliminary mapping to intensive monitoring of prairie dog population density. The data will be used to plan additional work needed to rank the potential of each site for black-footed ferret reintroduction. The site included Saratoga, Medicine Bow, Pathfinder and Shirley Basin.

50. Maguire, L.A. 1989. Managing black-footed ferret populations under uncertainty: capture and release decisions. Pp. 268-292, *in* U.S. Seal, E.T. Thorne, M.A. Bogan, and S.H. Anderson (eds.). Conservation biology of the black-footed ferret. Yale University Press, New Haven, CT.

Black-footed ferret management decisions are characterized by uncertainty because of stochastic events in small populations and ignorance about ferret biology. The purpose of this chapter is twofold: (1) to illustrate the application of formal methods for analyzing decisions under uncertainty to black-footed ferret management, using an analysis of capture and release decisions as an example; and (2) to draw conclusions from the analysis about research and management strategies concerning capture and release.

51. Maguire, L.A., T.W. Clark, R. Crete, R. Cada, C. Groves, M. Shaffer, and U.S. Seal. 1988.

Black-footed ferret recovery in Montana: a decision analysis. Wildlife Society Bulletin 16:111-120.

We used formal methods for analyzing decisions under uncertainty to compare alternative means of enhancing the recovery of black-footed ferrets in Montana. We considered active vs. passive searching for wild ferrets in Montana and strategies for managing any ferrets that might be found. We compared alternate strategies by estimating their effects on the probability that ferrets will become extinct in the wild in the next 5 years and the probability that captive breeding will produce sufficient ferrets for reintroduction into the wild during the same period. A consensus of expert opinion was used to estimate probabilities for the analysis.

The decision analysis showed that active searching could reduce the probability of extinction from about 0.99 to about 0.95. If ferrets are found, active management in the wild is the best option. A similar analysis of ferret habitat management in Montana showed that protecting and managing ferret habitat for future reintroductions could reduce the probability of extinction from about 0.95 to about 0.93. These methods for clarifying optimal strategies for ferret management in Montana could be applied elsewhere to enhance ferret recovery.

52. Martin, D. 1988. Black-footed ferret surveys - Statewide. Completion Report, April 15, 1987 to April 14, 1988. Pp. 36-41, *in* Endangered and Nongame Bird and Mammal Investigations, Annual Completion Report, April 15, 1987 to April 14, 1988. Wyoming Game and Fish Department.

Hundreds of black-footed ferret (BFF) sightings have been reported statewide since public awareness programs were initiated. Each observer is contacted and, based on sighting information, the investigator decides whether it warrants further investigation. Eighteen BFF sightings were reported to the Wyoming Game and Fish Department since April, 1987. Surveys were conducted at locations where BFF sightings were reported. Due to poor snow tracking conditions in some areas, surveys were not completed as scheduled. No BFFs were located.

53. Martin, D., and D. Belitsky. 1988. Black-footed ferret surveys - Meeteetse, Wyoming. Completion Report, April 15, 1987 to April 14, 1988. Pp. 42-46 *in* Endangered and Nongame Bird and Mammal Investigations, Annual Completion Report, April 15, 1987 to April 14, 1988. Wyoming Game and Fish Department.

Final results of the 1987 summer surveys to census the last known population of free-ranging black-footed ferrets (BFFs) at Meeteetse, Wyoming, are presented. Twenty-one white-tailed prairie dog colonies were surveyed, totalling approximately 2,184 ha. The 1987 distribution and status of prairie dog towns in the Meeteetse area were determined. Survey results showed no evidence of BFFs occupying the prairie dog colonies at Meeteeste.

54. May, R.M. 1986. The cautionary tale of the black-footed ferret. Nature 320:13-14.

Short discussion of some of the biological and political aspects of the extinction of the Meeteetse, WY, black-footed ferret population.

55. Mead, R.A., S. Neirinckx, and N.M. Czekala. 1990. Reproductive cycle of the steppe polecat (*Mustela eversmanni*). Journal of Reproduction and Fertility 88:353-360.

In laboratory conditions, in a natural photoperiod, testicular redevelopment began in late December. Maximal testis size was attained by the end of February. Testicular regression began in mid-May and was complete by the end of August. Oestrus was first observed in late March and continued throughout April. Females mated for the first time between 30 March and 8 April. Mating generally coincided with peak concentrations of urinary oestrone conjugates and when vaginal lavages contained >90% cornified epithelial cells. Blastocyst implantation occurred by Day 13 and the post-implantation period was 29 days. Gestation ranged from 39 to 43 days and first parturition occurred in mid-May. Concentrations of urinary oestrone conjugates and free progesterone were elevated during the first half of pregnancy, reaching maximum values at mid-pregnancy, and then gradually declined as parturition neared. Litter size of primiparous females averaged 6.8 young/female. Females that were pseudopregnant or lost their litters shortly after birth, and several with weaned kits, exhibited a second oestrus.

56. Meaney, C. 199[illegible] Black-footed ferrets in Colorado: A discovery. Bear Pause 19(1):8-9.

Discovery of a skull, left mandible, left and right fibula, right ulna, and two metatarsal bones of a black-footed ferret in South Park, Colorado, in August, 1989. The article also briefly discusses past ferret bone finds and the presumed causes of the ferret's demise in Colorado.

57. Miller, B.J. 1988. Conservation and behavior of the endangered black-footed ferret (*Mustela nigripes*) with a comparative analysis of reproductive behavior between black-footed ferrets and the congeneric domestic ferret (*Mustela [Putorius] furo*). Ph.D. Dissertation, University of Wyoming, Laramie, WY.

This dissertation includes five chapters. The first reviews biology of the black-footed ferret and discusses small population biology and captive propagation/reintroduction as a conservation tactic for threatened species. The second chapter is a descriptive ethology of the ferret. It defines and describes 74 discrete actions and groups then into 13 categories. The third chapter quantitatively defines and compares courtship behavior in the black-footed ferret and domestic ferret in the context of using the domestic ferret as a potential research surrogate. The fourth chapter quantitatively defines and compares behavior of gonadotropin induced estrus domestic ferrets and ferrets achieving estrus naturally. The fifth chapter investigates the significance of the prolonged copulations in the ferret.

58. Miller, B.J., and S.H. Anderson. 1989a. Courtship patterns in induced oestrous and natural oestrous domestic ferrets (*Mustela putorius furo*). Journal of Ethology 7:65-73.

Ten anoestrous female domestic ferrets (*Mustela putorius furo*) had estrus artificially induced by injection of porcine follicle stimulating hormone. Pre-copulatory activities were defined, quantitatively analyzed, compared to the pre-copulatory activities of 10 control females placed with the same male ferrets. Lag sequential analysis was used to prepare the behavioral matrices. Matrices were compared with an equality of proportions test. Courtship patterns between the 2 groups did not differ significantly.

59. Miller, B.J., and S.H. Anderson. 1989b. Failure of fertilization following abbreviated copulation in the ferret (*Mustela putorius furo*). Journal of Experimental Zoology 249:85-89.

In the first experiment, copulations in 10 domestic ferrets were interrupted 5 minutes after penetration. Ten control females were bred without interruption for the same males. Both control and experimental animals were rebred in the same manner to the same males 24 hours later. Sperm were present in all postcoital washes. We allowed all females from the first experiment to proceed to their expected date of parturition. All females who had been interrupted during copulation failed to conceive, whereas all controls produced litters. In a second experiment, the same procedure was followed; however, in this experiment, ferret oviducts and uteri were flushed 10 days after copulation. Nine control females (one failed to ovulate) averaged 5.2 blastocysts (range 2-10; S.D. = 5.8) per animal. Of nine interrupted copulation ferrets (one failed to ovulate), only one animal produced a single blastocyst. The interrupted copulation group averaged 4.4 unfertilized eggs (range 2-10; S.D. = 5.0) per female. Although ferrets ovulated during short copulations, those eggs are not likely to be fertilized.

60. Miller, B.J., S.H. Anderson, M.W. DonCarlos, and E.T. Thorne. 1988. Biology of the endangered black-footed ferret and the role of captive breeding in its conservation. Canadian Journal of Zoology 66:765-773.

The black-footed ferret (*Mustela nigripes*), one of the rarest mammals in the world, is apparently an obligate dependent on prairie dogs. Ferret numbers were probably reduced by habitat fragmentation. The last known wild colony, west of Meeteetse, Wyoming, was decimated by canine distemper in 1985. The few remaining ferrets exist in captivity. In this paper, we review aspects of the reproductive physiology and life history of the black-footed ferret with focus towards captive propagation and subsequent reintroduction of the species into natural habitat. We discuss the black-footed ferret in the context of small population biology and relate the value of captive propagation as a conservation tactic.

61. Miller, B., D. Biggins, C. Wemmer, R. Powell, and L. Calvo. 1989. Predator avoidance behaviors in captive raised ferrets (*Mustela eversmanni*). Northeast Regional Animal Behavior Meeting, November 10-12, 1989, Brown University, Providence, RI.

We exposed naive Siberian ferrets (aged 2, 3, and 4 mo.) to a swooping stuffed great horned owl and a stuffed badger mounted on a remote control toy truck frame. The first introduction was harmless, the second was accompanied by an aversive stimulus, then a third was harmless. Level of alert behavior (at 3 and 4 mo.)

increased significantly after a single aversive treatment with either predator model ($p<0.05$). Escape responses of naive ferrets did not differ between ages when exposed to the terrestrial predator, but 4 mo. old ferrets improved their escape times from the badger after a single aversive treatment ($p<0.05$). When exposed to the swooping owl, 4 mo. old naive ferrets showed a faster escape time than the other two age groups ($p<0.05$), and both 3 ($p<0.05$) and 4 ($p<0.10$) mo. old ferrets improved escape times from the owl after a single aversive treatment. This indicates an instinctive response to the avian predator model at 4 mo. of age, and a short term ability to remember a single aversive encounter with either a terrestrial or avian predator model at ages 3 and 4 mo.

62. Miller, B.J., G.E. Menkens, and S.H. Anderson. 1988. A field habitat model of black-footed ferrets. Pp. 98-102, *in* D.W. Uresk, G.L. Schenbeck, and R. Cefkin (Technical Coordinators). Eighth Great Plains wildlife damage control workshop proceedings, April 28-30, 1987, Rapid City, SD. General Technical Report RM-154. USDA Forest Service, Rocky Mountain Forest and Range Experimental Station, Fort Collins, CO.

We present a model to compare prairie dog complexes with known black-footed ferret habitat. The model assumes: 1) black-footed ferret populations require prairie dog colonies for survival, 2) prairie dog colonies can accommodate more black-footed ferret for each approximate 59 hectare increase in size, 3) a higher percentage of overall are covered by prairie dogs can accommodate more black-footed ferrets. We list four biological variables. They are: 1) total hectares in prairie dog colonies, 2) percent of total complex inhabited by prairie dogs, 3) intercolony distance, 4) an estimate of burrow density per hectare. In addition, two non-biological parameters are included. They are development potential and land ownership patterns. The model can provide an initial critique of a prairie dog complex for a black-footed ferret search or as a reintroduction site.

63. Minta, S.C., and T.W. Clark, 1989. Habitat suitability analysis of potential translocation sites for black-footed ferrets in northcentral Montana. Pp. 29-45 *in* T.W. Clark, D. Hinckley, & T. Rich (eds.) The prairie dog ecosystem: managing for biodiversity. Montana Bureau of Land Management Wildlife Technical Bulletin 2.

The Phillips Resource Area of northcentral Montana is a prime candidate for reintroduction of black-footed ferrets from captive-breeding programs. Most of the land containing black-tailed prairie dog (*Cynomys ludovicianus*) colonies is administered by the Bureau of Land Management, U.S. Fish and Wildlife Service - Charles M. Russell Wildlife Refuge, and Fort Belknap Indian Reservation. Colony surveys in 1981, 1984, and 1988 reveal colony growth and indicate healthy prairie dog populations. In 1988, 255 colonies totaled 28,540 acres (11,550 ha) and contained 1,236,808 burrows. Using the method of Biggins et al. (1988), we delineated four complexes encompassing 68.5 percent of these colonies. To assess the potential of each complex, we apply the black-footed ferret Habitat Suitability Index models of Houston et al. (1986) and Biggins et al. (1988), and we introduce variable and model revisions. Revisions include modification of variable functions and addition of variables derived from the design of ecological reserves. We also address the role of epidemiology, other nearby complexes and colonies, potential for prairie dog expansion, abundance of other predators, and future resources conflicts and ownership stability. We stress that HSI variable weight and relations and model form are flexible. Thus, we present the raw data and intermediate calculations.

64. Montana Black-footed Ferret Working Group. 1988. Montana prairie dog management guidelines. Montana State Office, Bureau of Land Management, Billings, MT. 14 pp.

This document provides prairie dog management guidelines for meeting five objectives. These objectives include the following: 1) Develop understanding, interest, and support for management of prairie dog ecosystems in Montana; 2) Maintain prairie dog ecosystems to ensure adequate habitats for the continued existence of threatened, endangered, and associated species; 3) Identify standards and techniques for managing prairie dog populations in Montana; 4) Monitor prairie dog ecosystems to determine the status and trend of populations of prairie dogs, threatened and endangered species, and species of special concern; and 5) Design research to find solutions to short and long-term biological and social problems related to prairie dog ecosystems.

65. Morkell, A. 1987. Black-footed ferret surveys - Statewide. Completion Report, April 15, 1986 to April 14, 1987. Pp. 59-68, *in* B. Oakleaf, D. Belitsky and S. Ritter (eds.),

Endangered and Nongame Bird and Mammal Investigations, Annual Completion Report, April 15, 1986 to April 14, 1987. Wyoming Game and Fish Department.

The report presents results of black-footed ferret (BFF) sighting investigations for the period of October 1, 1986 to April 1, 1987 and summarizes survey effort since 1983. Eighteen BFF sightings were reported to the Wyoming Game and Fish Department since October, 1986. No BFFs were located, although a trench digging resembling known BFF diggings was observed on a prairie dog colony in Hot Springs, CO. Additional field work is recommended at this location.

66. Morkell, A., D. Belitsky, J. Hanna, and B. Miller. 1987. Black-footed ferret surveys - Meeteetse, Wyoming. Completion Report, April 15, 1986 to April 14, 1987. Pp. 47-58, *in* B. Oakleaf, D. Belitsky and S. Ritter (eds.), Endangered and Nongame Bird and Mammal Investigations, Annual Completion Report, April 15, 1986 to April 14, 1987. Wyoming Game and Fish Department.

Results of summer and winter ferret surveys of the Meeteetse habitat are presented. The effort to remove all free-ranging ferrets is also described. Several recent publications summarize the 5 year history of the Meeteetse ferret population. This report includes data from 1984, 1985 and 1986 winter surveys and the 1986 summer survey. Numerous personnel from the following organizations assisted with the 1986 survey: University of Wyoming Cooperative Wildlife Research Unit, Wyoming Game and Fish Department, and the Denver Wildlife Research Center of the U.S. Fish and Wildlife Service.

67. Oakleaf, B. 1988. Why the Meeteetse ferrets had to come in. Wyoming Wildlife 52(3):29-33.

Popular discussion of the reasons behind the capture of the last known Meeteetse black-footed ferrets and future management directions.

68. Oakleaf, B. 1989. Putting them back. Wyoming Wildlife 53(3):15-23.

Popular article discussing black-footed ferret reintroduction efforts and management objectives. It briefly discusses some pertinent theory and potential conflicts and difficulties.

69. O'Brien, S.J., J.S. Martenson, M.A. Eichelberger, E.T. Thorne, and F. Wright. 1989. Genetic variation and molecular systematics of the black-footed ferret. Pp. 21-33, *in* U.S. Seal, E.T. Thorne, M.A. Bogan, and S.H. Anderson (eds.). Conservation biology of the black-footed ferret. Yale University Press, New Haven, CT.

Because of the troublesome natural history of the black-footed ferret, we sought to examine the genetic status of the only known population. An estimate of the extent of genetic variability in this population was derived using a survey of 46 gene-enzyme systems previously used to study genetic variability in other carnivore species. In addition, we have compared the electrophorectic mobility of homologous enzyme systems of four species of Mustela (*M. nigripes*, *M. Putorius*, *M. eversmanni*, and *M. vison*) in an attempt to resolve the phylogenetic relationship among these species. We have used these results to estimate the time elapsed since the black-footed ferret and its closest relative, the steppe polecat (*M. eversmanni*), have shared a common ancestor.

70. Orabona, A., and S. Anderson. 1987. White-tailed prairie dog monitoring. Completion Report, April 15, 1986 to April 14, 1987. Pp. 79-92, *in* B. Oakleaf, D. Belitsky and S. Ritter (eds.), Endangered and Nongame Bird and Mammal Investigations, Annual Completion Report, April 15, 1986 to April 14, 1987. Wyoming Game and Fish Department.

The Wyoming Game and Fish Department's Strategic Plan for management of black-footed ferrets emphasizes the need to identify potential reintroduction sites. Using the Meeteetse prairie dog complex as a model, the Shirley Basin complex was determined to be similar enough to warrant intensive study. The objective of this study was to determine the population status of white-tailed prairie dogs in the Shirley Basin complex, and to evaluate annual and seasonal white-tailed prairie dog population fluctuations and trends. The study found densities ranging from 8 to 20 prairie dogs per ha and a total population estimate of 1,901 prairie dogs. The sex ratio of pups was approximately 1:1 (1.12:1 actual). The sex ratio for adults, on the other hand, was 0.64:1. This may have been due to earlier male hibernation or greater male dispersal. There may have been problems due to prairie shooting on grid sites.

71. Orabona, A., and S. Anderson. 1988. White-tailed prairie dog monitoring, Shirley Basin. Completion Report, April 15, 1987 to April 14, 1988. Pp. 47-62, *in* Endangered and Nongame Bird and Mammal Investigations, Annual Completion Report, April 15, 1987 to April 14, 1988. Wyoming Game and Fish Department.

As the captive breeding program of black-footed ferrets (BFFs) realizes success, the continued evaluation of potential reintroduction sites is essential. One such site is the Shirley Basin white-tailed prairie dog complex. The population status of prairie dogs in the complex, including annual and seasonal trends, was studied. Sex ratios averaged 1.45:1 males: females for pups and 0.53:1 for adults. Population size for 1987 ranged from 8-29 per ha. The total population estimate increased from 1,901 in 1986 to 2,533 in 1987. Sylvatic plague was discovered in the Shirley Basin prairie dog complex during the 1987 field season. The problem of shooting mortality in 1986 was not encountered in 1987. Changes in methodology for the 1988 field season are discussed. Because the population trend data indicates an increase in total population, the potential for this site as a BFF reintroduction site is encouraging.

72. Paunovich, R., and S.C. Forrest. 1987. Activity of a wild black-footed ferret litter. Prairie Naturalist 19(3):159-162.

The daily activity and movement patterns of a litter of *Mustela nigripes* were observed during the summer of 1985. The litter changed den site locations 18 times during a 33-day observation period. Ferrets were active above ground on 93% of the nights observed, and activity was bimodal about dusk and dawn. Litter movement appeared to be motivated by white-tailed prairie dog (*Cynomys leucurus*) kills made by the mother, with subsequent movement to the site of the kill. The data support theoretical models of ferret bioenergetic demand of 9.7-0.9 prairie dogs/day/litter.

73. Reiger, G. 1987. Too many cooks: endangered species may be in danger of being studied to death. Field and Stream 92(7):15-16, 21.

Critique of wildlife management in North America. The author suggests that the biological side of the profession has become dominated by the political. He is especially critical of endangered species programs, which, he asserts, threatened to destroy the species they are set up to preserve due to impacts of too much unnecessary research. Grizzly bears and black-footed ferrets are highlighted.

74. Richardson, L. 1986. On the track of the last black-footed ferrets. Natural History 2/86:69-77.

Popular article describing research on the Meeteetse black-footed ferrets and the biological and ecological information discovered.

75. Richardson, L., T.W. Clark, S.C. Forrest, and T.M. Campbell, III. 1987. Winter ecology of black-footed ferrets (*Mustela nigripes*) at Meeteetse, Wyoming. American Midland Naturalist 117:225-239.

Snow-tracking was used in winters from 1981-1984 to examine movements, spatial patterns, hunting behavior and sign characteristics of a population of black-footed ferrets (*Mustela nigripes*) near Meeteetse, Wyoming. Nightly movements averaged 1406 m, increased from December to March, changed with temperature and breeding activity, and were nonlinear. Ferrets were active above ground from -1 to -38 °C and were inactive up to 6 nights and days. Activity areas for 3-8 nights ranged from 0.4-98.1 ha. Ferrets exhibited spatiotemporal separation and intrasexual territoriality. Ferrets selectively approached and urinated by mounded prairie dog (*Cynomys leucurus*) burrows, probably because they were prominent geographic features rather than preferred prey hibernaculae. Ferret activity was confined primarily to prairie dog colonies and prairie dogs were the major prey. Ferrets apparently cached prey. Diggings (0.6 per track route), urinations (0.7 per route) and markings (0.9 per route) were the most common ferret signs, and scats (0.1 per route) were least common. Diggings and snow-trenching rates were highest in December, but markings in snow peaked in February, coinciding with breeding activity.

76. Schroeder, M. 1987. The black-footed ferret. Pp. 446-455, *in* R.L. Di Silvestro (ed.), Audubon Wildlife Report, 1987. Academic Press, NY.

Overview of black-footed ferret biology and ecology and of the species' history and management through late 1986.

77. Schroeder, M. 1988. Endangered species considerations in prairie dog management. Pp. 123-124, *in* D.W. Uresk, G.L. Schenbeck, and R. Cefkin (Technical Coordinators), Eighth Great Plains wildlife damage control workshop proceedings, April 28-30, 1987, Rapid City, SD. General Technical Report RM-154. USDA Forest Service, Rocky Mountain Forest and Range Experimental Station, Fort Collins, CO.

Past prairie dog management has resulted in reduction of the prairie dog ecosystem upon which the black-footed ferret depends. This brief article traces the responsibilities of government agencies toward ferrets as endangered species legislation developed. It discusses requirements under the 1973 Endangered Species Act and the policies adopted by the U.S. Fish and Wildlife Service (FWS) to meet those requirements. Currently, the FWS requires consultation for any activity involving prairie dog habitat and standardized surveys on project sites which could contain ferrets.

78. Seal, U.S., E.T. Thorne, M.A. Bogan, and S.H. Anderson (eds.). 1989. Conservation biology and the black-footed ferret. Yale University Press, New Haven, CT. 302 pp.

Collection of articles from the workshop on reproductive biology of black-footed ferrets and small populations as they relate to conservation. For specific topics see individual author(s) (Anderson; Ballou; Ballou and Oakleaf; Brussard and Gilpin; Cole; DonCarlos, Miller, and Thorne; Flesness; Foose; Harris, Clark, and Shaffer; Lacy and Clark; Maguire; O'Brien, Martenson, Eichelberger, Thorne, and Wright; Thorne and D.W. Belitsky; Wildt and Goodrowe).

79. Thorne, E.T. 1986. Captive breeding and the single ferret. Wyoming Wildlife 50(12):29-35.

Popular historical account of the biological events and management decisions during the 1985 crash of the Meeteetse, WY, black-footed ferrets and the subsequent establishment of a captive breeding population in Sybille, WY.

80. Thorne, E.T. 1987. Captive propagation of the black-footed ferret in Wyoming. Pp. 419-424, *in* American Association of Zoology Parks and Aquariums, Regional Conference Proceedings, April 12-14, 1987, Colorado Springs, CO. American Association of Zoological Parks and Aquariums Publication, Syracuse, NY.

Discussion black-footed ferret captive breeding efforts through early 1987 and of the events leading up to the capture and initiation of the captive breeding program.

81. Thorne, E.T. 1988a. 1987. Black-footed ferret breeding season successful. Conservation Biology 2:11-12.

Brief discussion of the result of the 1987 black-footed ferret breeding season.

82. Thorne, E.T. 1988b. A future for ferrets. Wyoming Wildlife 52(10):20-27.

Popular account of the 1987 and 1988 black-footed ferret breeding seasons and future management directions.

83. Thorne, E.T. 1988c. Captive breeding of black-footed ferrets. Job Performance Report, Research Project Segment, July 1987 to September 1988. Pp. 65-92, *in* Game and Fish Research, Wyoming Game and Fish Department, Cheyenne, WY.

Thirty-four black-footed ferret kits were weaned as a result of the 1988 breeding season. Thirteen litters were produced by 14 females; 6 different male participated in the breeding. One mature female died in 1988, but the total population was increased to 58 animals. The use of surrogate animals was important to the success of the breeding season as well as research on reproductive biology of ferrets. Preparations were made to move a total of 15 kits born in 1988 the Henry Doorly Zoo in Omaha, Nebraska, and the National Zoological Park's Conservation and Research Center, Front Royal, Virginia.

84. Thorne, E.T., and D.W. Belitsky. 1989. Captive propagation and the current status of free-ranging black-footed ferrets in Wyoming. Pp. 223-234, *in* U.S. Seal, E.T. Thorne, M.A. Bogan, and S.H. Anderson (eds.). Conservation biology of the black-footed ferret. Yale University Press, New Haven, CT.

This chapter discusses (1) the events leading up to and resulting in the establishment of a captive population of black-footed ferrets for captive propagation, and (2) the status of free-ranging ferrets at Meeteetse in 1986.

85. Thorne, E.T., and R. Oakleaf. 1989. Species rescue for captive breeding: Black-footed ferret as an example. Pp. 6, *in* J.H.W. Gipps (Organizer). Abstracts from the Symposium on beyond captive Breeding: Re-introducing endangered species to the wild, November 24-25, 1989. The Zoological Society of London, The Mammal Society, and The Primate Society of Great Britain.

The black-footed ferret (*Mustela nigripes*) is among the world's most endangered mammals. Its precarious status is a direct result of habitat fragmentation through prairie dog (*Cynomys* spp.) eradication in the North American mid-western prairies. By the 1940s, habitat fragmentation reached the point at which extinction was inevitable without extensive intervention; but because known viable populations of black-footed ferrets were few until 1975 and nonexistent after that. Federal and State planning and commitment to recovery of black-footed ferrets were inadequate. Less than 4 years after discovery of the last known population near Meeteetse, Wyoming, in 1981, a captive breeding program was initiated to augment management of the free-ranging population. But a canine distemper epizootic led to extirpation of the colony and dependence on successful captive breeding if black-footed ferrets are to survive. Through the use of technical advice and a planning process, specific objectives were established to maintain genetic variation, increase and subdivide the captive population, and initiate early re-introduction. Captive breeding techniques were developed on schedule and meeting objective. Preparations are being made for experimental re-introduction in 1991.

86. Thorne, E.T., and E. Williams. 1988. Diseases and endangered species: the black-footed ferret as a recent example. Conservation Biology 2(1):66-73.

Diseases may play major roles in the conservation of endangered species. Although the threat of disease received extensive consideration and influenced research and management activities governing the endangered black-footed ferret (*Mustela nigripes*) in Wyoming, a canine distemper epizootic in 1985 severely affected a captive breeding program and led to extirpation of the species from the wild. This recent example of the catastrophic effect of epizootic disease in an endangered species is described in an historical context. In addition, examples are given of disease further endangering other rare species, including Mauritius pink pigeon, Pere David's deer, cranes, maned wolves, native Hawaiian birds, cheetahs, and others.

87. U.S. Fish and Wildlife Service. 1988. Black-footed ferret recovery plan. U.S. Fish and Wildlife Service, Denver, Colorado. 154 pp.

The plan outlines steps for recovery of the black-footed ferret (*Mustela nigripes*) throughout its historical range. It summarizes ferret biology and ecology; reviews its historical status, distribution, and past recovery efforts; discusses problem analysis and recovery strategies; and presents a stepdown outline of recovery objectives and an implementation schedule. The goal for black-footed ferret recovery is to: (1) increase the number of captive ferrets to a facility of 200 breeders by 1991, and (2) establish populations, which before breeding number 1,500 black-footed ferrets, in 10 or more populations in the wild.

88. Weinberg, D. 1986. Decline and fall of the black-footed ferret. Natural History 2/86:63-69.

Popular account of the decline and eventual extinction of the Meeteetse, Wyoming, population of black-footed ferrets. The article concentrates on the controversy surrounding ferret management decisions.

89. Wildt, D.E., M. Bush, C. Morton, F. Morton, and J.G. Howard. 1989. Semen characteristics and testosterone profiles in ferrets kept in a long-day photoperiod, and the influence of hCG timing and sperm dilution medium on pregnancy rate after laparoscopic insemination. Journal of Reproduction and Fertility 86:349-358.

We have used the domestic ferret for developing artificial breeding strategies for the black-footed ferret. Five domestic ferrets previously maintained for 12 weeks under a 16L:8D photoperiod were electroejaculated weekly for 15-65 weeks while continuing to be exposed to the prolonged light cycle. Two ferrets sustained spermatogenesis for 20 and 26 weeks, while sperm production in the remaining males either was sporadic or decreased, remained depressed and then increased to peak levels observed in other males. Regardless of the temporal spermatogenesis patterns within males, the number of electroejaculated spermatozoa with residual cytoplasmic droplets or abnormal acrosomes increased in all ferrets over time. Diluted ejaculates meeting artificial insemination criteria were deposited intravaginally or by transabdominal laparoscopy into the uterine horns of females treated 0 or 24 h earlier with 90 i.u. hCG. Vaginal insemination was ineffective (0 pregnancies in 10 attempts), but 17/24 ferrets (70.8%) inseminated laparoscopically became pregnant and delivered live young (mean litter size 5.2 kits). Number of motile spermatozoa deposited in utero (1.6-10.0 x 10^6 cells), presence of glycerol in the sperm dilution medium (0 versus 4%) and time of hCG administration (o versus 24 h before insemination) had no effect on pregnancy results or litter size.

90. **Wildt, D.E., and K.L. Goodrowe. 1989. The potential for embryo technology in the black-footed ferret. Pp. 160-176, *in* U.S. Seal, E.T. Thorne, M.A. Bogan, and S.H. Anderson (eds.). Conservation biology of the black-footed ferret. Yale University Press, New Haven, CT.**

Embryo technology provides the means for rapid dispersal of genetic material of outstanding individuals. Theoretically, the techniques of embryo collection, storage, and transfer as well as the formation of embryos by in vitro fertilization may eventually have an impact on conservation and artificial breeding of rare and endangered species. Embryo techniques that might be applied to the black-footed ferret are considered in this chapter. The usefulness of embryo techniques for black-footed ferret propagation will be determined ultimately by the availability of 3 essential resources: (1) animals, (2) expertise, and (3) equipment and supplies.

91. **Wildt, D.E., J. Howard, C. Morton, and M. Bush. 1987. Reproductive studies of the domestic ferret as an investigational model for the black-footed ferret. Pp. 382-383, *in* Proceedings of the First International Conference on Zoology and Avian Medicine.**

Although primary efforts to breed captive black-footed ferrets focus on natural breeding, recommendations have been made for formulating alternative artificial strategies. The present study was initiated to evaluate mustelid reproduction as well as the potential of artificial insemination (AI) using the domestic ferret as an animal model. Research animals included 5 adult males and 12 adult females maintained under a 16/8 hr light/dark cycle. Eight/12 AI ferrets became pregnant and delivered term offspring (6/8 treated with hCG 24 hr before and 2/4 treated with hCG coincident with the time of AI). The duration of gestation and number of young born ranged from 41-43 days and 3-6, respectively. These studies of the domestic ferret indicate that high-quality semen can be collected and maintained after electroejaculation and that live-born offspring can be produced after laparoscopic insemination. Assuming the seasonal onset of gametogenesis in black-footed ferrets, these results would suggest that laparoscopic AI may be a viable alternative for enhancing the captive propagation of this endangered species.

92. **Williams, E.S. 1987. Disease survey of carnivores near Meeteetse. Completion Report, April 15, 1986 to April 14, 1987. Pp. 93-106, *in* B. Oakleaf, D. Belitsky and S. Ritter (eds.), Endangered and Nongame Bird and Mammal Investigations, Annual Completion Report, April 15, 1986 to April 14, 1987. Wyoming Game and Fish Department.**

Canine distemper did not appear to be active in the Meeteetse area in 1986, based on lack of active cases of canine distemper in the carnivores examined and the fact that all animals with positive serum antibody titers to distemper with adults. The presence of serum antibodies to canine distemper in coyotes and badgers indicates at least some infected individuals of these species survive the disease. These species could be quite important in the epizootiology of canine distemper in the Meeteetse area by shedding virus into the environment. The presence of serum antibodies to *Yersinia pestis* in skunks, badgers and coyotes was expected. The use of serum for detection of prior exposure to *Yersinia pestis* was much more sensitive than the filter paper whole blood technique. The presence of parvovirus in coyotes and coronavirus of skunks is of unknown importance to black-footed ferrets. A variety of internal parasites are present in carnivores in the Meeteetse area; some could potentially infect black-footed ferrets. These would be unlikely to cause significant disease unless an individual received a large exposure or was immunosuppressed.

93. **Williams, E.S., E.T. Thorne, M.J.G. Appel, and D.W. Belitsky. 1988. Canine distemper in**

black-footed ferrets (*Mustela nigripes*) from Wyoming. Journal of Wildlife Diseases 24:387-398.

In September and October 1985, six black-footed ferrets (*Mustela nigripes*) were captured near Meeteetse, Wyoming, for captive propagation. Two days following capture an adult male showed signs of canine distemper and an adult female displayed similar signs 7 days postcapture. Subsequently the four remaining captive ferrets also developed canine distemper and all eventually died. Clinical signs included severe pruritus, hyperkeratosis and progressive loss of body condition. A few animals had intermittent diarrhea and respiratory disease. Intranuclear and intracytoplasmic inclusion bodies were numerous in epithelial tissues and two ferrets had a mild to moderate meningoencephalitis. Canine distemper virus was isolated from four animals and paramyxovirus nucleocapsids were observed by electron micropsy of feces from all affected ferrets. Antibodies to canine distemper virus were found in sera of badgers (*Taxidea taxus*) and coyotes (*Canis latrans*) collected in the Meeteetse area in 1986. Most free-ranging black-footed ferrets in the colony apparently died of canine distemper during the summer and fall of 1985. An attempt was made to capture all surviving animals in the affected are in order to abort the epizootic and provide ferrets for captive propagation.

94-97. Wyoming Game and Fish Department. 1986-1989. The black-footed ferret newsletter. Volumes 3-6. Wyoming Game and Fish Department, Cheyenne, WY.

Published quarterly until 1988 and biannually thereafter, these newsletters provide popular accounts of black-footed ferret conservation. Included are descriptions and explanations of black-footed ferret research projects and results, health news, captive breeding plans and updates, and other management objectives and efforts.

98-100. Wyoming Game and Fish Department. 1988-1990. The drumming post. Volumes 1-3. Wyoming Game and Fish Department, Cheyenne, WY.

Biannual nongame newsletter of the Wyoming Game and Fish Department with occasional updates on black-footed ferret recovery efforts.

101. Wyoming Game and Fish Department. 1987. A strategic plan for the management of black-footed ferrets in Wyoming. Wyoming Game and Fish Department Report, Cheyenne, WY.

This plan was developed to inform and educate the citizenry of the United States about recent and future black-footed ferret discoveries, associated research activities, management and captive propagation found in the state of Wyoming, as well as species specific fund raising opportunities. It is a comprehensive plan, designed to utilize a variety of communication mediums to enhance the public's knowledge, awareness, and understanding of this endangered species.

As with any plan, potential manpower, time, and monetary limitations are recognized, although all stated goals and objectives, and tasks are deemed obtainable.

IN PRESS

102. Barnes, A.M. In Press. A review of plague (*Yersinia pestis*) infection and its relevance to prairie dog populations and the black-footed ferret. Black-footed Ferret/Prairie Dog Conference, June 1989, Fort Collins, CO. Federal Building, US Fish and Wildlife Service, Helena, MT.

Prairie dogs (all four species of *Cynomys*) are considered major amplifying hosts of plague in the western United States where the disease is endemic and often epizootic. Prairie dogs play an extremely important role by amplifying the magnitude of plague in the environment, broadcasting the disease to other animal populations, and extending its distribution. The importance of prairie dog populations as the prey base for the black-footed ferret adds another important ecological dimension to plague in prairie dogs. This paper briefly reviews plague in the western United States to provide a conceptual picture of its epizootiology and addresses as points of discussion a number of questions concerning plague epizootic and its impact on the future of the black-footed ferret.

103. Biggins, D.E., L.R. Hanebury, B.J. Miller, and R.A. Powell. In Press. Release of Siberian Polecats (*Mustela eversmanni*) on a prairie dog colony. Abstracts, 70th Annual Meeting of the American Society of Mammalogists, June 1990, Frostburg, MD.

Thirteen reproductively sterilized Siberian polecats were radio-tagged and released on a colony of black-tailed prairie dogs (*Cynomys ludovicianus*) in southeastern Wyoming. Objectives were to test release and monitoring strategies to be used during reintroduction of black-footed ferrets (*M. nigripes*), and to examine the polecat's ability to adapt to ferret habitat. Before release, polecats were given experience killing prairie dogs and were given mild aversive conditioning for predator avoidance. Seven polecats were given supplemental food (dead prairie dogs) after release, and 6 polecats received no additional support. Mean post-release survival was 5.3 days (range 0.4-17.4 days). Polecats were killed by coyotes (*Canis latrans*), badgers (*Taxidea taxus*), and a hawk or eagle. Mean survival for supplementally fed animals was 7.7 days, compared to 2.5 days for others. Polecat activity was mainly nocturnal, and their movements were similar to movement of radio-tagged black-footed ferrets. Additional trials with surrogate polecats will be conducted before scheduled reintroduction of ferrets in 1991.

104. Clark, T.W. In Press. The endangered black-footed ferret. Chapter 14 *in* B.A. Wilcox, P.F. Brussard, and B.G. Marcot (eds.), The management of viable populations: Concepts, theory, and cases. Standford Center for Biological Conservation, Standford, CA.

The black-footed ferret is one of the world's most critically endangered mammals. Agricultural interests and federal and state rodent control programs drastically eliminated ferret habitat — prairie dog colonies — and fragmented the remainder into small patches, thus rendering isolated ferret populations highly vulnerable to extinction. This chapter discusses the biological challenge of ferret recovery. It provides a review of the results obtained from research on ferrets in Meeteetse, Wyoming, including paleobiology, biogeography, and systematics; population characteristics; population genetic considerations; behavior and activity patterns; habitat and preserve characteristics; and conservation management and species recovery.

105. Curry, P.T., M. Straley, W. Burgess, M. Parker, R. Atherton, and R. Kitchin. In Press. Computer analysis of sperm mortality and morphology of European, Siberian, and black-footed ferret sperm. Society for the Study of Reproduction, 21st Annual Meeting, August 1988 (Abstract).

106. Curry, P.T., T. Ziemer, M. Straley, R.W. Atherton, and R. M. Kitchin. In Press. A comparison of sperm morphology and silver nitrate staining characteristics in the domestic ferret and the black-footed ferret. Gamete Research.

107. Fitzgerald, J.P. In Press. Plague ecology in Gunnison's prairie dogs and some management suggestions regarding black-footed ferret recovery efforts. Black-footed Ferret/ Prairie Dog Conference, June 1989, Fort Collins, CO. Federal Building, US Fish and Wildlife Service, Helena, MT.

A number of challenges face biologists attempting to achieve recovery of black-footed ferrets (*Mustela nigripes*) in view of the recent outbreak of plague in white-tailed prairie dogs (*Cynomys leucurus*) and distemper in ferrets in Meeteetse, Wyoming. This paper examines the history of plague (*Yersinia pestis*) in prairie dogs, presents observation on plague ecology in the Gunnison's prairie dog (*C. gunnisoni*) in Colorado, and makes some comparisons with the recent epizootic at Meeteetse reported by Ubico et al. (1988). Black-footed ferret recovery efforts are also addressed.

108. Klebanoff, A., S. Minta, A. Hastings, and T. Clark. In Press. An age-dependent predation model: Black-footed ferrets vs. prairie dogs. SIAM.

The black-footed ferret is a weasel-like carnivore that preys almost exclusively upon prairie dogs in central North America. This tightly coupled system and the endangered status of ferrets motivated our predation model. We formulate an age-dependent model, clearly stating and comparing assumptions with the actual biological system. We build tenable parameters and values into the model in order to make predictions based on "real" data. Species-specific population data and energetic models, as well as general mustelid features, are the basis of ferret inputs. Extensive population data from several prairie dog species are used to create a "generic" prairie dog. A Holling Type III functional response and sigmoidal birth and survival functions describe ferrets living in a single, large colony of prairie dogs. The model consists of discrete-time equations for the annual birth pulse for each species, with the remaining year governed by a system of seven differential equations which allow both populations to decrease from predation and other mortality factors. We normalize the model and show that age dependence is destabilizing, except within a narrow range of values for ferret survival and birth functions. These values are close to but greater than our initial values. Sensitivity analysis reveals that general stability can be achieved by slightly increasing the hunting efficiency for the ferret. We suggest that higher prairie dog densities than previously predicted from energetic-based models may be necessary to ensure a stable ferret/prairie dog system. Finally, our results indicate that system stability is likely to be enhanced if patch dynamics are accounted for. Because wild black-footed ferret are virtually extinct, our results may be a useful tool for black-footed ferret recovery efforts, particularly for planning reintroduction of captive-reared specimens.

109. Mead, R.A., and S. Neirinckx. In Press. Photomanipulation of sexual maturation and breeding cycle of the steppe polecat (*Mustela eversmanni*) and other techniques for more rapid propagation of the species. The Journal of Experimental Zoology.

Twenty steppe polecats were divided into 2 groups, each consisting of 4 males and 6 females, and subjected to either a natural photoperiod (controls) or alternating periods of short (8 h light/16 h dark for 8-9 weeks) and long days (16 h light/8 h dark for 16-20 weeks). The experimental photoperiod significantly accelerated sexual maturation in both sexes, with males developing maximal testis size within 57 days and females breeding after an average of 52 days exposure to 16L/8D. Males in the experimental group completed 2 1/2 testicular cycles and participated in mating during 3 successive breeding seasons during the 18 month period whereas males in the control group completed a single testicular cycle and only had an opportunity to mate during a single breeding season. Females in the experimental group produced 3 litters whereas females in the control group only gave birth to a single litter. Litter size averaged $6.9\ ^{+}\ 2.0$ (n=23) and did not significantly differ with age, parity, or treatment. Pseudopregnant females returned to estrus within 12 days after the expected date of parturition, were bred, and gave birth to kits. Polecats which were subjected to the experimental photoperiods completed more molting cycles and underwent more photoperiod-induced changes in body weight than those in the control group.

Death or removal of kits within 8 days after birth resulted in 12/12 females returning to estrus within 6-26 days. Eleven of these females were remated and gave birth to kits. Eight domestic ferrets readily accepted neonatal polecat kits and 5 successfully reared kits, although kit survival was quite poor. These results clearly demonstrate the potential of these techniques for inducing precocious sexual maturation and production of multiple litters each year.

110. Miller, B.J., and S.H. Anderson. In Press a. Comparison of black-footed ferret and domestic ferret courtship. Zoo Biology.

Because of the scarcity of the endangered black-footed ferret (*Mustela nigripes*) and the amount of knowledge necessary for their conservation, surrogate research can play an important role in recovery. In this paper, we investigate surrogate behavioral research potential by comparing courtship behavior of the black-footed ferret to the congeneric domestic ferret (*M. putorius furo*). Ten female domestic ferrets were bred to five male domestic ferrets and eight female black-footed ferrets were bred to five black-footed ferret males. Courtship activities were defined, analyzed, and quantitatively compared between both groups. Lag sequence analysis was used to prepare the behavioral matrices, and matrice cells were compared between groups with an equality of proportions test. Courtship patterns did not differ significantly between the two closely related species, and the domestic ferret would probably be an adequate surrogate for behavioral research on the black-footed ferret.

111. Miller, B.J., and S.H. Anderson. In Press b. Ethology of the endangered black-footed ferret. Ethology. (also in Advances in Ethology, Paul Parey Publishers, Berlin).

This paper qualitatively describes basic social and maintenance activities of the endangered black-footed ferret. Field observations were the sole source of previous behavioral information. Black-footed ferrets, however, are nocturnal and fossorial, and many aspects of their behavioral repertoire are difficult to detect in nature. Captive animals offer an opportunity to record activities unobservable in the wild. Knowledge of black-footed ferret behavior will benefit both captive propagation and the reintroduction attempts in the effort to conserve this rare mammal.

We obtained data from both free-ranging and captive animals and grouped activities into 13 categories: Special senses, locomotion and postures, grooming and comfort, elimination and scent marking, digging, vocalizations, predatory behavior, eating and drinking, activity times, reproductive behavior, juvenile development and maternal behavior, agonistic behavior, and interspecific relationships.

In the ethogram, we describe black-footed ferret behavior patterns. Then in the discussion, we speculate on the significance of these activities in the evolved life history patterns for black-footed ferrets. Topics included in this section are: body conformation and energetics, water conservation, digging, scent marking, reproduction, play behavior, predation, and similarities between free-ranging and captive ferrets. We also discuss potential reasons for ferrets using a fixed gestation length in their reproductive strategy when many mustelids delay implantation and discuss the importance of the prairie dog burrow to the ferret.

112. Miller, B.J., C. Wemmer, D. Biggins and R. Reading. In Press. A proposal to conserve black-footed ferrets and the prairie dog ecosystem. Environmental Management.

Prairie dogs (*Cynomys* spp.) have been poisoned throughout this century because of grazing competition with livestock. Recent evidence showed these early claims were exaggerated, but animal control was already entrenched in government policy. As a result, ongoing government subsidized poisoning had reduced prairie dogs to about 2% of their former distribution. The reduction of prairie dogs diminished species diversity in the arid grasslands of North America, including the potential extinction of the black-footed ferret (*Mustela nigripes*). Cost/benefit analysis revealed that poisoning costs more than any grazing benefits accrued. This analysis did not consider the long term costs of reversing ecosystem degradation, the intangible value of biological diversity as a public benefit, nor the depletion of biotic resources as a loss of actual or potential wealth. The government presently finances the poisoning policy and the preservation of endangered species like the black-footed ferret, two apparently conflicting programs. We, therefore, propose an integrated management program that considers both interests. We propose that federal monies allocated to the poisoning program be converted into a rebate for ranchers who manage livestock while preserving the prairie dog community. This would redirect funds already allocated to prairie dog eradication into an incentive for ranchers who manage for livestock and wildlife. Livestock interests and grassland biotic diversity would both benefit.

Additions to Casey et al. (1986)

113. Ballew, H. 1985. Stalking the prairie bandit. Orion 4(4):44-55.

Popular account of the discovery of and early research on black-footed ferrets in Meeteetse, Wyoming.

114. Casey, D.E. 1985. Black-footed ferret. Skylight Book. Dodd, Mead and Company, NY.

Children's book about black-footed ferret natural history and conservation efforts.

115. Madson, C. 1985. Ferrets need your help. Wyoming Wildlife 49(11):10-13.

Popular article appealing public financial support for a captive breeding facility in Wyoming. Reasons presented for the necessity of establishing a captive population.

116. Thorne, E.T. 1984. Doctoring the black-footed ferret. Wyoming Wildlife 48:11-19.

Popular article discussing diseases potentially impacting black-footed ferrets and preventive measures used during ferret research activities. The article deals primarily with plague in prairie dogs and canine distemper in ferrets.

117-118. Wyoming Game and Fish Department. 1984-1985. The black-footed ferret newsletter. Volumes 1-2. Wyoming Game and Fish Department, Cheyenne, WY.

Published quarterly until 1988 and biannually thereafter, these newsletters provide popular accounts of black-footed ferret conservation. Included are descriptions and explanations of black-footed ferret research projects and results, health news, captive breeding plans and updates, and other management objectives and efforts.

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